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Annual Performance Evaluation of Ground Water Remediation From March 2004 Through March 2005 at the Tuba City, Arizona, Disposal Site

July 2005

U.S. Department of Energy

Office of Legacy Management

Work Performed Under DOE Contract No. DE–AC01–02GJ79491
for the U.S. Department of Energy Office of Legacy Management.
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Work Performed by S.M. Stoller Corporation under DOE Contract No. DE–AC01–02GJ79491
for the U.S. Department of Energy, Grand Junction, Colorado

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1.0 Introduction

1.1 Purpose of Report

This report evaluates the performance of the ground water remediation system at the U.S. Department of Energy (DOE) Land Management site near Tuba City, Arizona, for the period of March 2004 through March 2005. The site is located in Coconino County, Arizona, within the Navajo Nation and near Hopi Reservation land (Figure 1). Ground water in an underlying sandstone aquifer is contaminated by inorganic constituents from former uranium-ore milling at the site, including nitrate, uranium, and sulfate, the primary site contaminants. A pump-and-treat remediation system constructed to restore ground water quality began full operation in mid-2002.

1.2 Ground Water Remediation System

The ground water remediation system currently operates 25 extraction wells completed within the most contaminated region of the aquifer. The extracted water is conveyed in underground piping to an on-site facility where it is mechanically distilled following ion exchange pretreatment. Engineered solar evaporation ponds receive the waste liquid (brine), and an infiltration trench located upgradient of the contaminant plume returns the treated water (distillate) to the aquifer. Six injection wells originally intended to create a hydraulic barrier at the downgradient limit of contamination remain unused for that purpose. Eight additional extraction wells (wells 1126 through 1133) installed in summer 2004 were not in service during this review period. These wells, and four monitoring wells recently converted to extraction use (wells 935, 942, 936, and 938), will be in service by summer 2005. Figure 2 shows the primary site features.

1.3 Ground Water Compliance Strategy

The ground water compliance strategy for the Tuba City site, as defined in the *Phase I Ground Water Compliance Action Plan for the Tuba City, Arizona, UMTRA Site* (GCAP) (DOE 1999), is to achieve applicable cleanup levels through active remediation of those portions of the aquifer affected by previous site activities. Cleanup levels for the aquifer comprise restoration "standards" (requirements of 40 CFR 192 [Uranium Mill Tailings Radiation Control Act]), and restoration "goals" (cleanup levels requested by the Navajo Nation but not required by 40 CFR 192).

Ground water contaminants requiring active remediation at the site are molybdenum, nitrate, selenium, sulfate, and uranium [DOE 1999]). Restoration standards (see Table 1) for these constituents, except sulfate, correspond to a maximum concentration limit (MCL) in ground water as established in 40 CFR 192. Sulfate is not regulated by 40 CFR 192. However, a restoration standard was adopted for this constituent because it is present in ground water at the site at concentrations that cause an excess potential risk (DOE 1999). The Navajo Nation also requested that the distillate not exceed 20 mg/L of sodium.

Table 1. Ground Water Remediation Goals

Constituent/Property	Cleanup Level	Baseline Concentrations in Plume
Nitrate[a]	10 mg/L as N (44 mg/L as NO_3^-)	840–1,500 mg/L
Molybdenum[a]	0.10 mg/L	0.01–0.58 mg/L
Selenium[a]	0.01 mg/L	0.01–0.10 mg/L
Uranium[a]	30 pCi/L (0.044 mg/L) U-234 + U-238	0.3–0.6 mg/L
Sulfate[a]	250 mg/L	1,700–3,500 mg/L
TDS[b]	500 mg/L	3,500–10,000 mg/L
Chloride[b]	250 mg/L	20–440 mg/L
pH[b]	6.5–8.5	6.3–7.6
Corrosivity[b]	not corrosive	not applicable

[a]Restoration standard
[b]Restoration goal

1.4 Performance Monitoring and Reporting

Performance of the ground water remediation system is evaluated yearly upon receipt of water quality and water level monitoring data obtained in August and February of each year. These data are compared to baseline conditions to evaluate the capture zone of the extraction system, movement of contamination in the aquifer, and concentration trends, as measures of aquifer restoration progress.

Additionally, the composition and volumetric totals of treatment system inflow and outflows are determined weekly, and each extraction well is sampled monthly for water quality analysis. These data are used to track the extraction and treatment volumes, contaminant mass recovery, distillate composition, and waste production.

The semi-annual monitoring events covered in this report occurred in August 2004 and February 2005. Monitoring data obtained between 1998 and March 2002 represent baseline conditions at the site (DOE 2003). The 13-month review period for this report includes March 2004 through March 2005.

1.5 Ground Water Hydrology

The Tuba City site lies on the middle of three alluvial terraces associated with ancestral flow in Moenkopi Wash, located about 1.25 miles southeast of the site. The regionally extensive Navajo Sandstone, a massively cross-bedded, friable, fine to very fine sandstone and siltstone, underlies coarse, semi-indurated, Quaternary alluvium at most terrace locations. Loose dune sand and silt is prevalent to depths of up to 20 feet except where bedrock slopes and cliffs dominate the terrace escarpments. Regional bedrock dip is about one degree to the northeast.

Within about 200 feet below ground, the eolian dune deposits of the "classic" Navajo Sandstone become interbedded with fine-grained alluvium more typical of the underlying Kayenta Formation. This "inter-tonguing interval" is 400 to 450 feet thick. Occasional thin (≤ 2 feet [ft]), resistant limestone beds occur throughout as relicts of former playa lakes. Locally, the Kayenta Formation consists of 100 ft or more of slope-forming, flat-lying red silt and fine sand.

Ground water beneath the Tuba City site occurs in the regionally extensive "N" multiple-aquifer (Cooley et al. 1969), which in the site area comprises the Navajo Sandstone. From the ambient water table about 50 to 60 feet below ground at the site, the saturated zone extends through the inter-tonguing interval to the upper contact of the Kayenta Formation.

Ground water flow beneath the site is southeast to Moenkopi Wash. There, regional discharge occurs from a laterally extensive (miles) spring zone that outcrops near the exposed base of the inter-tonguing interval. Some local discharge of ground water from higher in the formation occurs to sustain scattered populations of desert phreatophytes, such as in the "greasewood area" shown in Figure 2, where depth to water is only about 20 feet. Plant uptake requires this water to reside in fractured, decomposed, or unconsolidated material rather than competent bedrock. Figure A-1 in Appendix A depicts a conceptual model of the site hydrogeology.

1.5.1 Vertical Discretization of the N-Aquifer

Site hydrostratigraphy is discretized into 50-ft intervals, or "horizons," each with a letter designation. The top of the middle terrace, nominally 5,050 feet in elevation, marks the top of the uppermost horizon (Horizon A). Horizons A, B, C, and possibly D span the interval of "classic" Navajo Sandstone beneath the site, whereas the depths of Horizons E through J include the regions of the inter-tonguing interval. Horizons K, L, and M include the lower intertonguing interval and possibly the upper Kayenta Formation. These stratigraphic relationships to aquifer horizon are shown in Figure A-1.

Related to ground surface topography, the uppermost horizon on the lower terrace progresses from Horizon C to D, north to south. The steep topography at Moenkopi Wash intersects Horizons E through G. Ground water remediation at the site focuses primarily on the upper 250 ft of the bedrock aquifer (Horizons A through E).

Color-coding in Figure 2 identifies the horizon in which the mid-point of each well screen is located for extraction wells (round symbols) and monitoring wells (square symbols). Figure A-2 of Appendix A is a cross-section schematic of the placement depth of well screens in relation to aquifer horizon for all project wells.

2.0 Treatment System Performance

2.1 Bulk Treatment Parameters

During the review period the treatment plant operated for 344 of 392 total days, for a net on-stream factor of 88 percent. About 48-million gallons of water were treated during this 56-week period resulting in an average operating rate of 97 gpm and an effective rate (downtime included) of 85 gpm. The operating capacity of the treatment plant as currently configured is about 120 gallons per minute. Total ground water treatment as of April 1, 2005 was approximately 136-million gallons, equivalent to about 11 percent of the total estimated volume of uranium-contaminated ground water present before the start of remediation (see Section 5.3).

Figure 3 shows the feed rate to the treatment plant and the corresponding concentration of nitrate and sulfate determined from weekly composite samples since the start of remediation. Uranium concentration in the bulk feed for the same period is shown in Figure 4. These figures indicate that contaminant concentrations entering the treatment system have remained relatively stable while the treatment plant is operating. A slight downward trend in uranium concentrations over time is indicated in Figure 4. The masses of nitrate, sulfate, and uranium extracted during the current review period, based on the weekly inflow volume and feed composition are respectively, 159,000 lbs, 389,000 lbs, and 102 lbs (Table 2).

Table 2. Treatment System Performance Summary

Contaminant	Typical Concentration (mg/L)	Distillate Concentration (mg/L)	Mass Removed during Review Period (lb)
Nitrate	400	5-15	159,000
Sulfate	970	20-40	389,000
Uranium	0.25	0.004-0.01	102

2.2 Distillate Quality

Concentrations of nitrate, sulfate, and uranium in the distillate averaged about 9, 30, and 0.008 mg/L, respectively, during the review period (Table 2 and Figure 5). Total dissolved solids (TDS) ranged between about 40 and 80 mg/L, and chloride concentrations were generally less than 2 mg/L with little variation. These results indicate highly effective contaminant removal and very high quality of water returned to the aquifer.

2.3 Return Flow to the Aquifer

Weekly production of wastewater sent to the evaporation pond averaged about 7 percent of the total inflow rate for the year in review. The balance of the treated water (93 percent) was returned to the aquifer at the infiltration trench.

3.0 Extraction & Infiltration System Performance

3.1 Extraction Wells

In Figure 2, the extraction wells that operated during this review period are those labeled 1101 to 1125. They are constructed of 6-inch diameter Schedule 40 PVC solid casing and 6-inch, continuous V-wrap stainless steel (0.017-inch slot). A filter pack of 20-40 graded silica sand completes the 2-in annulus to 30 or 40 feet above the screen slots. Screen lengths are 150-ft, extending from the bottom half of Horizon B to the mid-depth of Horizon E, except for wells 1116, 1117, and 1118, which have 100-ft screens that extend nearly to the base of Horizon D. Extraction wells 1126 to 1133, installed in September 2004, are of similar specification but consist of 4-inch diameter casing and screen. In addition, they are much shallower such that their 30-ft screen is located across most of Horizon B. These latter wells will become operational in summer 2005, but currently serve as monitoring wells. All extraction pumps are 1/4 to 1/3 horsepower submersible type, located 10 to 15 ft above the bottom of the well. Pumping is interrupted when the water level reaches the pump intake and resumes after a prescribed period of water level recovery.

The production rate of the well field is generally equivalent to the treatment plant feed rate shown in Figures 3 and 4. Although not obvious in the figures, total well-field production increased during the review period by about 10 gpm after wells 1116 and 1117 were returned to service in July after pump failures in March and December 2003, respectively. In addition, pump controls were adjusted in July 2004 to maximize well yield and minimize on-off cycling due to excessive drawdown. As a result, pumping is nearly continuous at all but wells 1123 and 1120. Continuous pumping rates range between 2 and 5.5 gpm, and average 4 gpm. Wells 1120 and 1123 operate half-time at rates of 7 and 0.5 gpm, respectively. In map view, there is no apparent relationship between location and extraction rate. The operational history of each extraction well for the evaluation period is included in Appendix A, Table A−1.

4.0 Extent of Ground Water Contamination

Figures 6a through 14a illustrate the concentrations of nitrate, sulfate, and uranium in ground water before the start of remediation. Most of the information is from sample collection in March 2002 but extends back to 1999 for some locations. These figures define contaminant distribution during the baseline period in the various aquifer horizons shown. Figures 6b through 14b show contaminant distribution in February 2005 (new extraction wells 1126 through 1133 were not operating during the review period). Although each well location sampled for the respective period is shown, a concentration value is posted only where the applicable remediation standard was exceeded. Tabulated analytical results for August 2004, February 2005, and the baseline period for each contaminant requiring remediation are included in Appendix B.

In map view, the horizontal extents of contamination in the various horizons are not significantly different from the baseline condition, indicating no lateral spreading of the contaminant plume (sentinel well 271, located southwest of well 267, was not sampled in February 2005 but remained uncontaminated as of August 2005; see also Section 5.1 for additional discussion regarding plume expansion). The new wells installed on the middle terrace (extraction wells 1126 through 1133 and monitoring wells 281 through 283) confirmed suspected contamination in Horizons A and B at each of those locations within the previously defined plume boundary.

Before installation of wells 272 through 276 in August and September 2004, discrete depth monitoring of Horizons C and D in the main area of the plume was not possible. Sample collection in February 2005 indicates contamination at the respective depths of wells 273 and 275 (Figures 7b, 10b, and 13b), but no contamination in the screened intervals at the remaining locations (wells 272, 274, and 276). The absence of contamination in Horizon E (see Figures 8b, 11b, and 14b) suggests no downward plume movement to this depth. Deeper in the aquifer, contamination remains at Horizon I wells 254 and 256, and Horizon M wells 255 and 257. As discussed in Section 6.2, the origin of contamination at these latter locations is attributed to downward leakage of shallower ground water through failed annular seals. Contamination at well 251 (Horizon E) during the later portion of the baseline period, before which the contamination was not present, is possibly of the same origin. Contaminant concentrations at well 251 have since decreased to below cleanup standards in response to ground water extraction.

On the lower terrace, nitrate and sulfate contamination remains minor and localized to one or two wells (Figures 7b and 10b). Uranium contamination at the single lower terrace location decreased to less than the remediation standard during the review period (see also Section 5.1 for additional information on concentration trends). New monitor wells installed on the lower terrace during the review period (wells 277, 278, and 279) confirmed the absence of contamination at those locations.

4.1 Capture Analysis

4.1.1 Water Table Configuration

Figure 15 shows the phreatic surface for the baseline period estimated using water levels in Horizon A and B monitor wells for the middle terrace and Horizon C wells for the lower terrace. On the middle terrace, water levels from deeper wells are not representative of water table conditions because of pronounced vertical hydraulic gradients (see Section 4.1.4), and within the network of monitoring wells between the escarpment and greasewood area, the water table beneath the lower terrace occurs in Horizon C. The horizontal direction of ground water flow was predominantly south during the baseline period. A steeper hydraulic gradient corresponds to aquifer thinning at the escarpment (Figure 15).

Figure 16 shows a similarly constructed water table for February 2005. At that time, ground water mounding and increased hydraulic gradients in Horizons A and B were evident along the north edge of the disposal cell due to infiltration of treatment system distillate at the trench. Comparison of Figures 15 and 16 indicates that operation of the extraction wells has significantly depressed the water table and consequently changed flow directions in the shallow ground water throughout the area of extraction where shallow monitor wells are present. Insufficient well control in the area of ground water extraction on the east side of the site prevents analysis of water table conditions there. The water table underlying the escarpment and lower terrace appears unaffected by ground water extraction.

4.1.1.1 Infiltration Trench

The infiltration trench is constructed into bedrock along the north side of the site (see Figure 2 for trench location). Distillate enters the trench at its mid-point from where it can flow in either direction in perforated pipe embedded in a 3 ft thick gravel pack. Through mid-2003, non-uniform infiltration caused greater than 20 ft of ground water mounding beneath the southwest section of the trench but only about 1 ft beneath the northeast section. The ground water mound has become more symmetrical since November 2003 when flow valves were installed and all inflowing water was diverted to the northeast segment of the trench. Water level hydrographs for wells located near the respective ends of the trench (wells 687 and 688, Figure C-1, Appendix C) indicated that the northeast section would soon experience excessive mounding if a correction were not made. Since April 2005 therefore, a portion of the inflow was diverted to the southwest section of the trench.

The absence of ground water in new wells 284 and 285 (see Figure 2 for location), screened across the contact of the terrace alluvium and bedrock immediately downgradient of the trench, indicates that mounding has not over-topped the trench to saturate the alluvium. Ground water flow from the trench area is south to the extraction wells to assist in flushing the main region of contamination.

4.1.2 Water Level Drawdown

Figure 17 further illustrates the effect of ground water extraction and infiltration on water levels in Horizons A and B by showing the difference between baseline and February 2005 water levels as the computed drawdown. Figures 18 and 19 plot the drawdowns for the deeper horizons for the same period. Positive values identify locations where the water level in February 2005 is less than the baseline value. Negative values, such as those at the wells surrounding the infiltration trench (Figure 17), indicate that water levels at the respective locations are presently higher than during the base-line period. Well hydrographs in Appendix C provide an additional view of water level drawdowns over time at numerous site monitoring wells.

The overall pattern of water level drawdown reflects three-dimensional converging flow to the extraction wells. Because the water level in each extraction well is generally maintained near the base of the well (Horizon D or E), the greatest drawdown (44 ft) is observed at the Horizon E wells (wells 251 and 268) located within the extraction field. Among all monitor wells, the intakes of wells 251 and 268 are nearest in radial distance to the interval of ground water extraction. Consistent with convergent flow, drawdown at the remaining monitor wells is observed to decrease with distance from the extraction zone. Although water level drawdown in response to ground water extraction affects the entire aquifer within the region of contamination, it does not imply capture of all contaminated ground water.

4.1.3 Horizontal Capture

Figures 20 and 21 depict the estimated zone of ground water capture by the extraction system for Horizons A and B combined, and Horizons C and D combined, respectively. In these figures, the extent of contamination (solid line) is generalized from the distributions presented in Figures 6a through 14b. The dashed line represents the capture zone as determined by hydraulic gradient vector analysis within respective depth intervals using a model of triangulation with linear interpolation and February 2005 water levels. Water levels in the extraction wells were not included in either analysis.

The results indicate that the estimated capture zone of Horizons A and B (Figure 20), within which all ground water ultimately reaches an extraction well, does not fully encompass the extent of contamination. The residual area between the extent of contamination and capture zone on the middle terrace is the targeted zone for the extraction wells installed in 2004. In the east area of the site, where A and B Horizon monitoring wells are absent, the estimated capture zone assumes that significant drawdown (20 ft) in Horizon C at wells 683 and 684 (not contaminated) implies local capture of the shallower water. Vector analysis predicts that contamination in Horizons C and D wells on the middle terrace is fully captured (Figure 21). The horizontal extent of capture in Horizon E and deeper cannot be determined with the available wells completed in those horizons. This limitation is of no consequence because contamination is absent from these horizons.

4.1.4 Vertical Capture

Hydrographs included in Appendix C for selected sets of co-located monitor wells illustrate that at a given location, the piezometric head is a function of well-intake depth. This relationship clearly identifies vertical flow components throughout the entire monitored thickness of the aquifer, both before and since the start of ground water remediation. With few exceptions, the vertical potentials were downward during the baseline period.

Since that time, the magnitude of downward flow in the horizons above the extraction interval has increased, as seen as the greater water level differences in the hydrographs for the respective locations of well pairs 265/266, 263/264, 908/912, and 909/932, since about mid-2002 (see Appendix C, Figures C-4 through C-7). In the main region of contamination, these increased gradients imply capture of ground water from the upper horizons by the extraction wells.

In the deeper horizons, vertical gradients are now generally upward to the extraction intakes. For example, the vertical flow potentials have reversed to upward between Horizons M, I, and E at co-located wells 268/256/257 in response to ground water extraction (Figure C-8). A similar result between Horizons E and I, and possibly M, is apparent at the location of wells 251/252/253 (see Figure C-9, the monitoring record is incomplete for well 253, a former Horizon M well that was abandoned in 2001). A downward flow potential remains between Horizon I and M at wells 254/255 (Figure C-10); however, there is an upward gradient at that location between Horizon I (well 254) and Horizon D (well 277). The apparent vertical flow divide at this location implies ground water capture possibly to Horizon I but not Horizon M.

Because the observed vertical influence of the extraction wells extends much deeper than the presumed depth of contamination, it is likely that the remediation system captures the full vertical extent of the contaminant plume. Although ground water extraction has no affect on downward flow between Horizons D and G at wells 915 and 916 (Figure C-11), this region of the aquifer is not contaminated. Downward flow potentials in lower terrace ground water also remain unaffected by ground water extraction (Figure C-12) but contamination there is only minor and limited to the shallowest horizon and there is no evidence of vertical or lateral spreading of contamination in the lower terrace ground water.

5.0 Remediation Progress

5.1 Contaminant Concentration Trends at Monitor Wells

Appendix D contains time-series graphs of nitrate, sulfate, and uranium concentrations, respectively, in ground water at selected monitor wells located throughout the project area.

Within Horizons A and B, wells 940, 941, and 942 are nearest the south side of the disposal cell and so are likely to first detect return flow from the infiltration trench as a pronounced decrease in contaminant concentration. Such trending at these locations has not yet been observed (see Figure D−1 through D−3). Assuming porous media flow under the observed water table gradient (Figure 16) and hydraulic conductivity of 1 ft/day, the calculated travel time from the infiltration trench to well 940 is 17 years, which is greater than the cumulative remediation period to date.

Farther south in the mid-section of the plume (near Horizon A and B wells 262, 906, 908, 934, 935, and 936), concentrations generally remain relatively stable, with local exceptions of either increasing or decreasing trends. Toward the outer (south) margin of the plume (near wells 263, 265, 267, and 909), contaminant concentrations are relatively stable or decreasing. Horizon A and B sentinel wells, specifically those located near the plume boundary (wells 271, 683, 684, 914, and 921), remain uncontaminated with the exception of minor but stable nitrate contamination at well 929, indicating no significant expansion of the contaminant plume (Figures D−4 through D−6).

Stable concentrations below remediation standards in Horizon C and D wells 264, 266, 915, and 932 (Figures D−7 through D−8) indicates no southward plume expansion to these locations at this depth of the aquifer. In these figures, elevated nitrate and sulfate concentrations at well 912 (Horizon C) are seen to decrease over time, which also indicates that contaminants are not spreading to the west of that location. In ground water beneath the lower terrace, uranium contamination did not exceed the restoration standard at any location during the past year. Previously, uranium contamination in lower terrace ground water was limited to low levels at co-located wells 691 and 1003. These are also the only wells with appreciable nitrate and sulfate contamination on the lower terrace. Stable concentration trends have not developed for these constituents at these wells. At three other nearby wells, stable nitrate values only marginally exceed the restoration standard. Migration of the very localized and relatively low magnitude contamination on the lower terrace apparently is not significant, as indicated by persistent background levels at nearby wells located farther downgradient. Contaminant concentration plots for lower terrace monitor wells are include in Appendix D (Figures D−10 through D−12).

5.2 Contaminant Concentration Trends at Extraction Wells

Figures 22, 23, and 24 illustrate concentration trends at the extraction wells for nitrate, sulfate, and uranium, respectively. For each contaminant, the trend at most wells is of decreasing concentration as contaminant mass is removed from the aquifer. Appendix E contains concentration plots for each extraction well based on the monthly on-site sampling and analysis (in Appendix E, concentration units are mg/L for nitrate as NO_3 and sulfate, and µg/L for uranium).

Figures 25, 26, and 27 are identical to the previous three figures but at a finer concentration scale to highlight occurrences of ground water extraction at concentrations less than the respective remediation standards. In a summary of that information, Table 3 identifies that at no location is the extract below the remediation standard for all three contaminants, although very nearly so at wells 1113 and 1125.

Table 3. Pumping Wells where a Contaminant Concentration is Below the Remediation Standard in the Extract

Nitrate	Sulfate	Uranium
--	1107	--
--	1112	1112
1113[a]	1113	1113
--	--	1114
--	1116	1116
--	--	1117
--	1123	1123
1125[a]	1125	1125

[a]Concentration is currently 45 mg/L nitrate as NO_3.

5.3 Contaminant Inventory and Removal Rates

Table 4 compares cumulative quantities of contamination removed from the aquifer as of April 1, 2005. Calculation methods to estimate the initial volume of contaminated ground water and initial contaminant mass listed in Table 4 are included in Appendix F. The listed initial mass of solute in ground water above remediation standards assumes a geometric average of measured baseline concentrations at numerous monitoring wells, per respective contaminant, in the corresponding estimated volume of contaminated ground water.

By these estimates, at current mass recovery rates of about 2 to 5 percent per year, ground water restoration will require between 20 and 50 years to complete since its inception in mid-2002. The corresponding minimum volume of extracted ground water, assuming constant withdrawal of 85 gpm, is 890-million gallons, approximately equivalent to one estimated pore volume of the contaminant plume.

Table 4. Summary of Cumulative Mass and Volume Recovery

Contaminant	Initial Mass (lb)[a]	Cumulative Mass Removed (lb)	Cumulative Percent Mass Reduction	Initial Volume (gal)[a]	Volume Treated (gal)	Percent Plume Volume Reduction
Nitrate	9,500,000	459,000	5	1.2E+09	135,900,000	11
Sulfate	20,150,000	1,123,000	6	1.2E+09	135,900,000	11
Uranium	2,300	325	14	1.2E+09	135,900,000	11

[a]Source: see Appendix F

5.3.1 Aquifer Restoration Index

Using a similar approach to that described in the preceding section, but independent of the estimated volume of contaminated ground water, the average concentration of a contaminant, when computed for each sampling event from a selected group of wells provides an additional measure of restoration progress when viewed over time. By this method, the composition of the ground water plume is represented as a single concentration value for a given contaminant at a given time. Figures 28 and 29 illustrate respectively how the geometric mean of the sulfate and uranium concentration for the individual sampling events varies since the baseline period. The selected monitor wells for this analysis are those located throughout the contaminant plume and sampled most regularly. Appendix G provides calculation information for this performance metric.

Despite the small increment of change and the relatively brief period of observation, the results presented in Figures 28 and 29 suggest a developing trend showing the effects of remediation in reducing the bulk concentration of the uranium and sulfate plume (nitrate results not analyzed). Linear projection of these data predict a total restoration time of 20 years since the inception of active remediation in mid-2002. This compares to an estimated 25 years to remove one pore volume of the initial contaminant plume (Table 4) at the current extraction rate of approximately 4 percent per year.

6.0 Special Topics

6.1 Concentration Rebound Study

A field study conducted during January 2004 evaluated the extent of contaminant rebound at the extraction wells after a scheduled 9-day maintenance shutdown (DOE 2004a). This was done to determine if contaminant removal could be enhanced by cyclic or “pulsed” pumping of the extraction wells (periods of pumping and non pumping of a given well or group of wells). Test results showed significant concentration rebound at most locations after the wells were idle followed by rapidly decreasing concentrations once pumping resumed. Because the overall benefit was short-lived (< 1 day), effective pulsed pumping would require rapid cycling. The associated operational and maintenance requirements suggest that pulsed pumping is not practical at this time.

6.2 Deep Wells

DOE issued a draft report in April 2004 (DOE 2004b) addressing the origin of ground water contamination at wells 251 through 257, installed in May 2000 and comprising the deepest wells at the site (up to 700 ft deep). In September 2000, significant grout accumulation in the bottom of well 253 was discovered. A sudden increase in contaminant concentration also occurred at that time. Previous samplings or well 253 indicated that contaminant concentrations in the screened interval (600 to 700 ft deep) were consistent with background levels. These findings indicated that the annual seal had failed, thus allowing downward migration of contaminants through the well bore, and so the well was soon abandoned.

A similar pattern of apparent well failure and delayed arrival of contamination to the screened interval occurred later at several other deep wells. Further investigation using down-hole video imaging during October 2000 and August 2002 identified grout seeping through the screen slots and accumulations of 10 to 20 feet of grout in the bottom of wells 254 and 256. About 5-ft of grout accumulated in well 256 during this 2-yr period. Fifteen to 20 ft of unidentified foreign material was also observed at the bottom of well 255. Imaging of well 257 was not conducted. Visual inspection of samples collected at well 254 in November 2003 confirmed the material in the bottom of that well to be grout.

In their report, DOE cited these and other lines of evidence in concluding that the apparent contamination of the deep wells is the result of failed annular seals and consequent downward flow of ground water through the well bore from the shallower contaminated horizons. Ambient downward flow potentials before the start of ground water remediation provided the necessary driving force. Since the start of active remediation, deep vertical flow potentials have reversed to upward at well pair 251/252, and the contamination in the screened interval of well 251 (Horizon E) has decreased to less than the remediation standards. Well 252 (Horizon I) has shown no evidence of contamination at any time.

Vertical flow potentials have also reversed to upward at well pair 256/257 in response to pumping. At well 256 (Horizon I), slightly elevated concentrations of nitrate, sulfate, and uranium have gradually decreased from peak levels in February 2002 such that only nitrate, at 48 mg/L, presently exceeds its restoration standard. As of February 2005, deep well 257 (Horizon M) is contaminated only by sulfate, but concentrations of that constituent continue to rise (see Appendix D, Figures D−13 through D−15 for time-series concentration graphs for the deep wells).

A downward flow potential remains between Horizons I and M at well pair 254/255, but shallower in the aquifer at that location, upward flow is indicated between Horizon I (well 254) and Horizon D (well 273), which should limit downward migration of contamination (see also Section 4.1.4). Both nitrate and sulfate continue to rise at well 254 to now exceed restoration goals by an order of magnitude, while uranium has simultaneously decreased from its peak of 0.21 to 0.09 mg/L between in February 2002 and 2005. As of February 2005, deep well 255 (Horizon M) is contaminated only by sulfate, but concentrations of that constituent continue to rise (see Appendix D). Similar to well 257, sulfate contamination in the absence of other site related constituents, possibly originates from the bentonite grout used to complete the wells.

As per the recommendations in DOE 2004b, proceedings are underway to abandon wells 254, 255, 256, and 257. The abandonment will occur during calendar year 2005. Deep wells 251 and 252 will be retained to maintain at-depth monitoring capability.

6.3 Well Field Expansion

Eight ground water extraction wells (wells 1126 to 1133) and 14 monitoring wells (wells 272 to 285) were installed during August and September 2004. The extraction wells will capture contaminated ground water in portions of the contaminant plume on the middle terrace that are currently unaffected by pumping. Based on contaminant concentration data for paired monitoring wells along the escarpment separating the middle and lower terraces (wells 263/264, 265/266, 909/932), the new extraction wells were installed to intercept Horizon B only to thus minimize capture of deeper ground water in this area that is not contaminated. Two of the three primary site contaminants exceed their respective restoration standards at each new extraction well. Preliminary flow rates for the new extraction wells range from about 0.5 to 3 gpm. These rates are not unexpectedly low considering the corresponding screens lengths (30 to 40 ft) are much shorter than those of the previously installed extraction wells (150 ft). The new extraction wells will begin operating in summer 2005.

Data uses for the new monitoring wells include: (1) determine ground water quality and capture in Horizon D in the main area of pumping (new monitor wells 272-276), (2) evaluate the capture zone of the new extraction wells (new monitor wells 281-283), (3) determine vertical flow relationships and water quality on the lower terrace near the greasewood area (new monitor wells 277-280), and (4) evaluate performance of the infiltration trench (new monitor wells 284 and 285). Data obtained from the new monitoring wells (and the non-operating new extraction wells) are incorporated in previous sections of this report.

6.4 Aquifer Isolation Tests

In March and June, 2004, field testing was conducted to evaluate the vertical distribution of contamination in the aquifer using three existing extraction wells. The objective of the tests was to determine if the wells penetrate uncontaminated intervals of the aquifer at depth that do not require capture and treatment. None of the tests recognized a well-defined base of contamination, but interpretation of test results was subject to considerable uncertainty arising from the test methods and field conditions (DOE 2005). Monitoring results for newly installed wells completed in Horizon D (wells 272-276) and mass balance analysis (DOE 2005) suggest that contamination in Horizon D is not pervasive but rather may be a localized occurrence. Currently, there are no plans to modify the existing extraction wells for the purpose of limiting ground water extraction from deeper portions of their screened interval. Additional field investigation of contaminant stratification may be conducted, which could eventually lead to a pumping scheme that focuses on the shallow Horizons A through C.

6.5 Geologic Reconnaissance

Field investigation of the Navajo Sandstone was conducted on January 12 to 14, 2005 by project personnel to identify features that might affect hydrogeological conditions at the site. This activity was prompted by depth-dependent water levels in wells and drill holes in the area of the middle terrace near the escarpment. Water levels in shallow wells (< 100 ft) are about 20 to 30 ft higher than the wells 50 to 100 feet deeper in the area. For example, at the location of well 1130, the initial borehole remained open at a depth of about 75 ft for more than one week during which the water level remained at about 60 ft below ground surface. In an adjacent borehole advanced to 125 ft, the static water level was about 90 ft below ground surface. Lithologic contrasts to account for the water level difference were not apparent during drilling. However, the field reconnaissance and additional review of project well logs tentatively identified a depositional bounding surface, possibly of low permeability, in this depth interval. Such a feature, acting locally either as a leaky aquitard or aquiclude could account in part for the locally strong downward flow gradient. The low permeability interval, and perhaps similar others, may also explain decreasing contaminant concentrations with depth across Horizons A through D.

7.0 Year in Review Summary

- On-stream extraction and treatment flow rates meet design objectives.
- Distillate quality meets or exceeds design objectives.
- Return flow to the aquifer as a percentage of extracted water meets design objectives.

- The current configuration and operation of the extraction system effectively captures the region of maximum ground water contamination.
- The current configuration and operation of the extraction system likely captures the full vertical extent of ground water contamination.
- Plume expansion is not significant on either the middle or lower terrace.
- Uranium concentrations have decreased to less than the restoration standard at all lower terrace monitoring locations.
- New extraction wells installed in 2004 will extend the capture zone to include regions of contamination on the middle terrace currently not captured.
- Developing bulk concentration trends indicate measurable progress in contaminant mass removal from the aquifer.

8.0 Recommendations

- Reduce ground water monitoring (except that conducted for treatment plant operations) to one annual event.
- Continue ground water extraction, treatment, and infiltration as currently conducted, with the addition of the new extraction wells to become operational in summer 2005.

9.0 References

Cooley, M.E., J.W. Harshbarger, J.P. Akers, and W.F. Hardt, 1969. *Regional Hydrogeology of the Navajo and Hopi Indian Reservations, Arizona, New Mexico and Utah*, U.S. Geological Survey Professional Paper 521-A.

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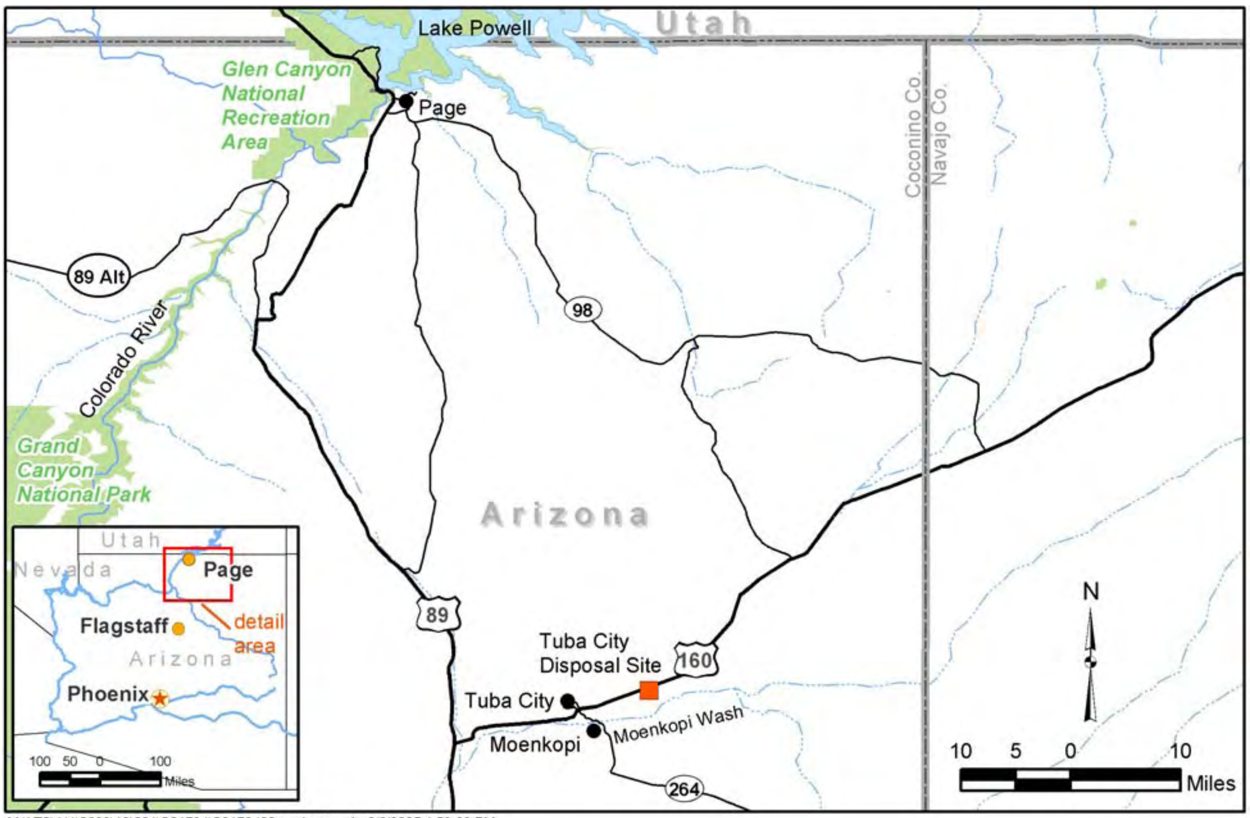

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Figure 1. Tuba City Site Location

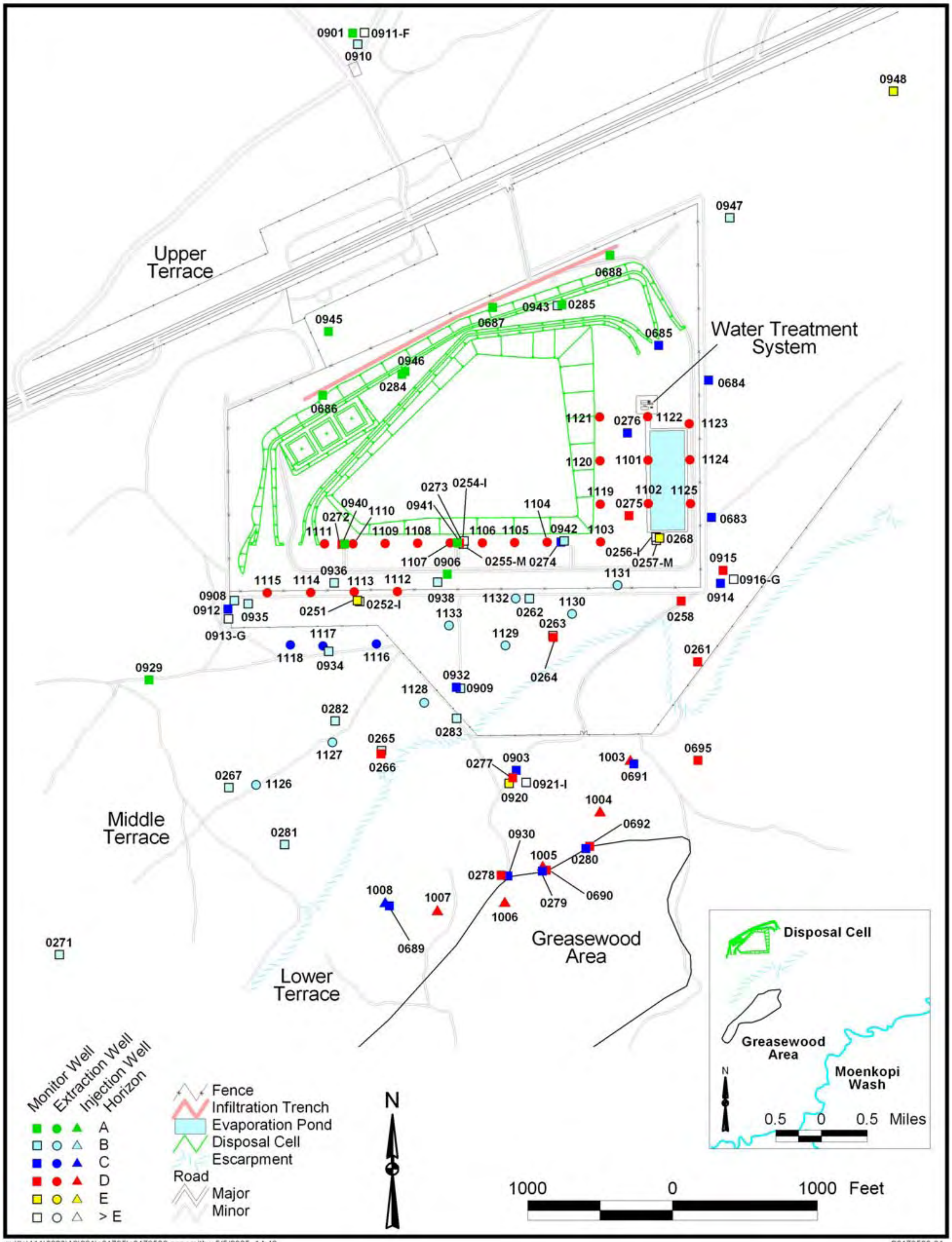

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Figure 2. Tuba City Site Features and Well Locations

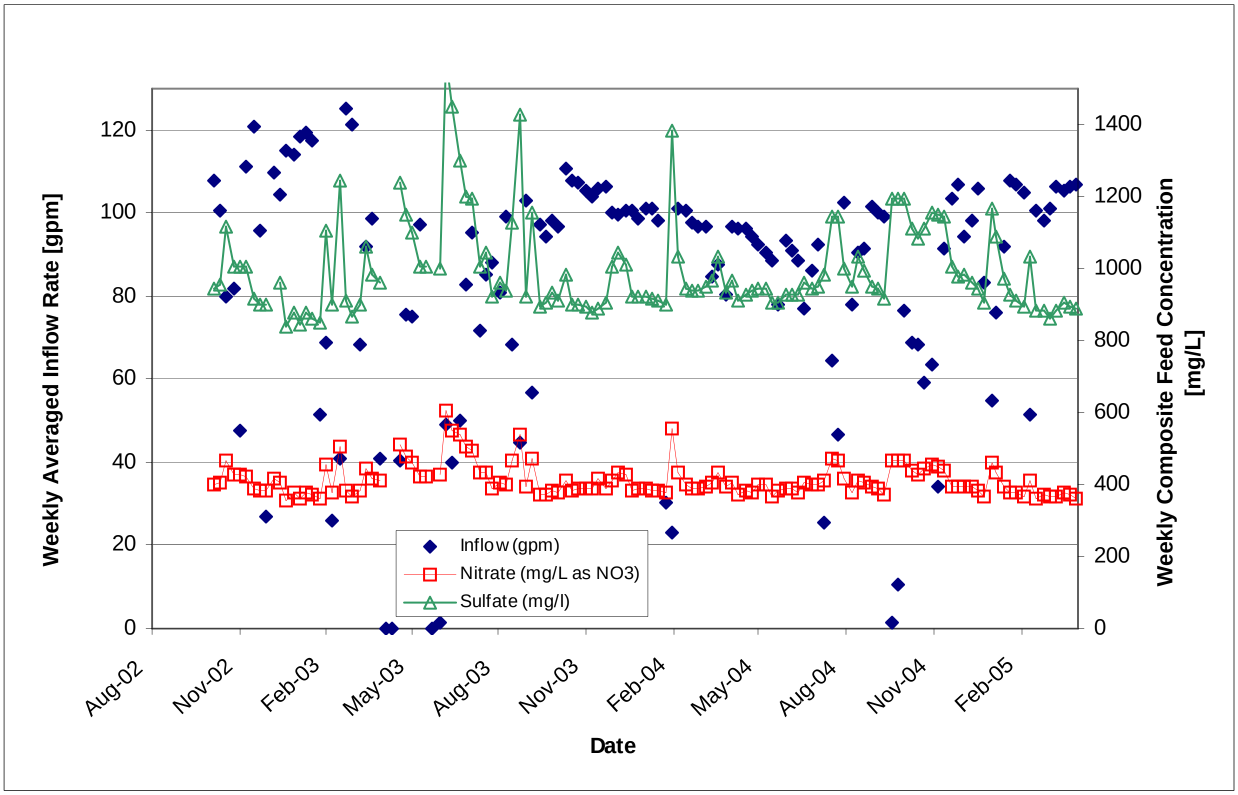

Figure 3. Treatment Plant Inflow Rate and Nitrate and Sulfate Concentration

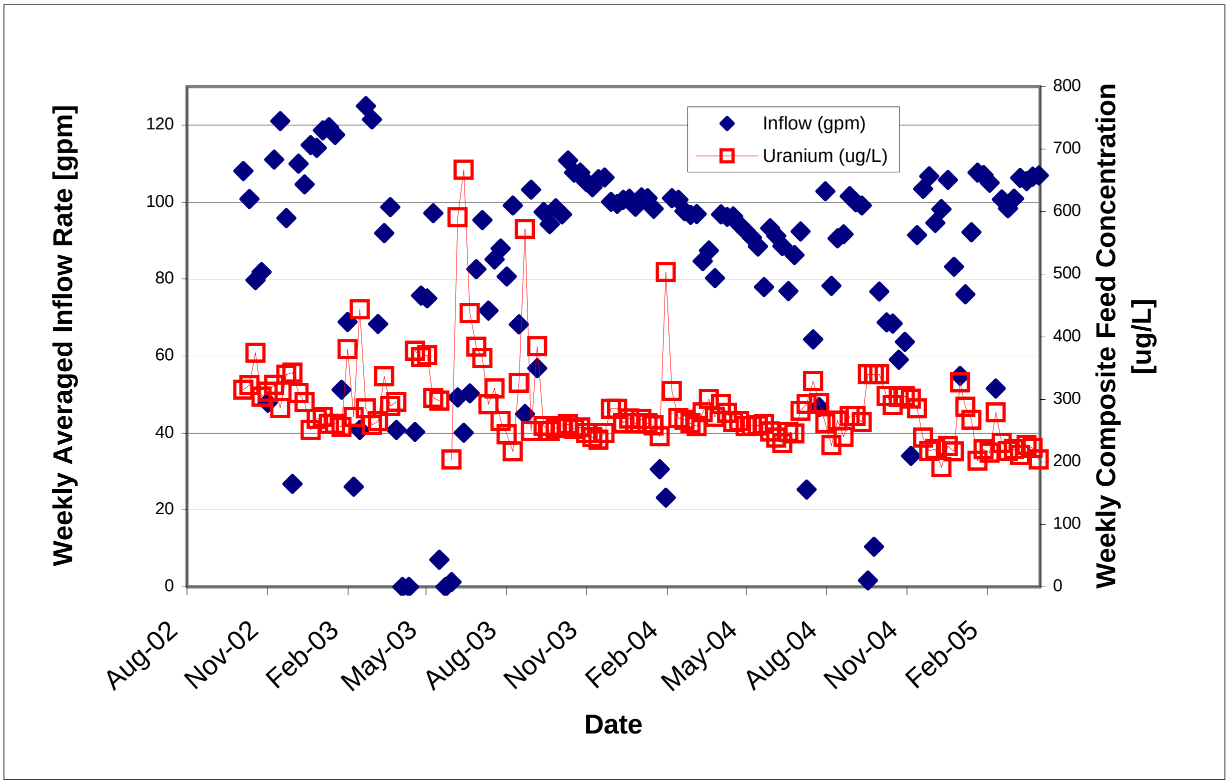

Figure 4. Treatment Plant Inflow Rate and Uranium Concentration

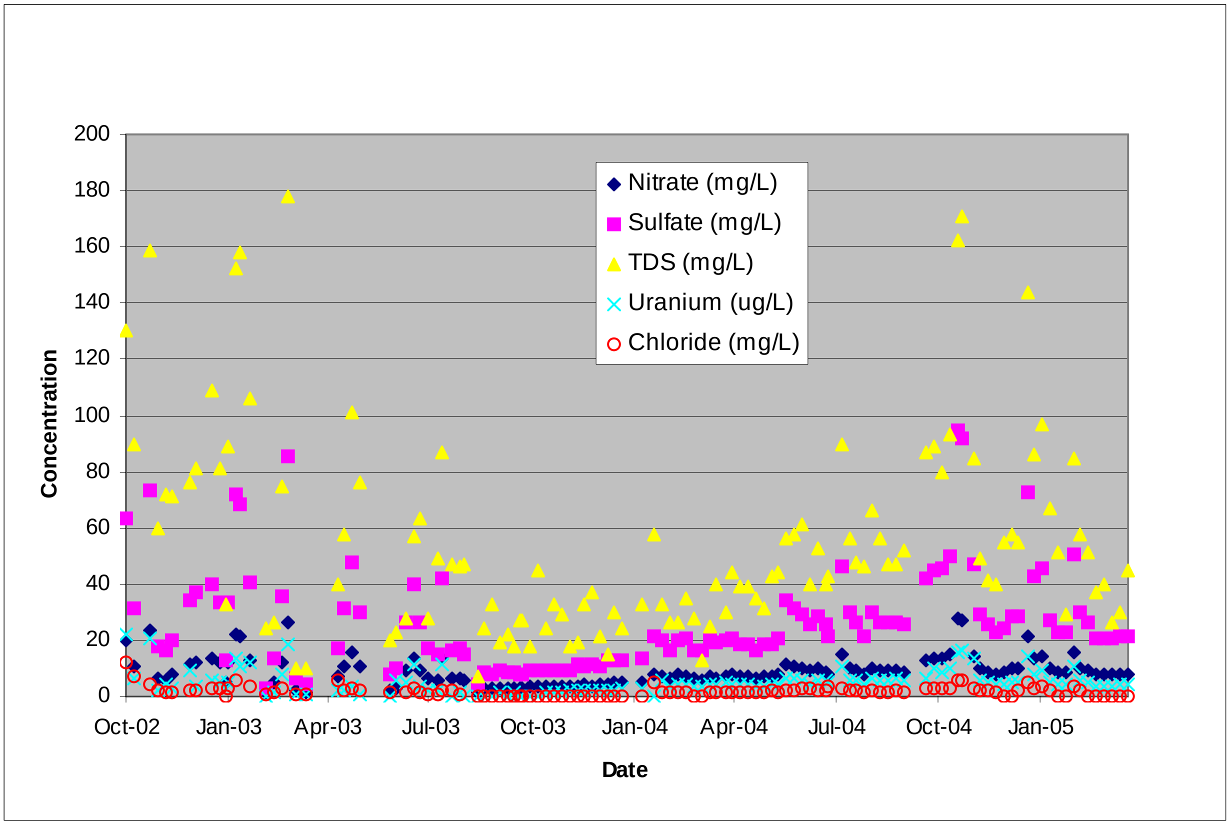

Figure 5. Treatment Plant Distillate Quality

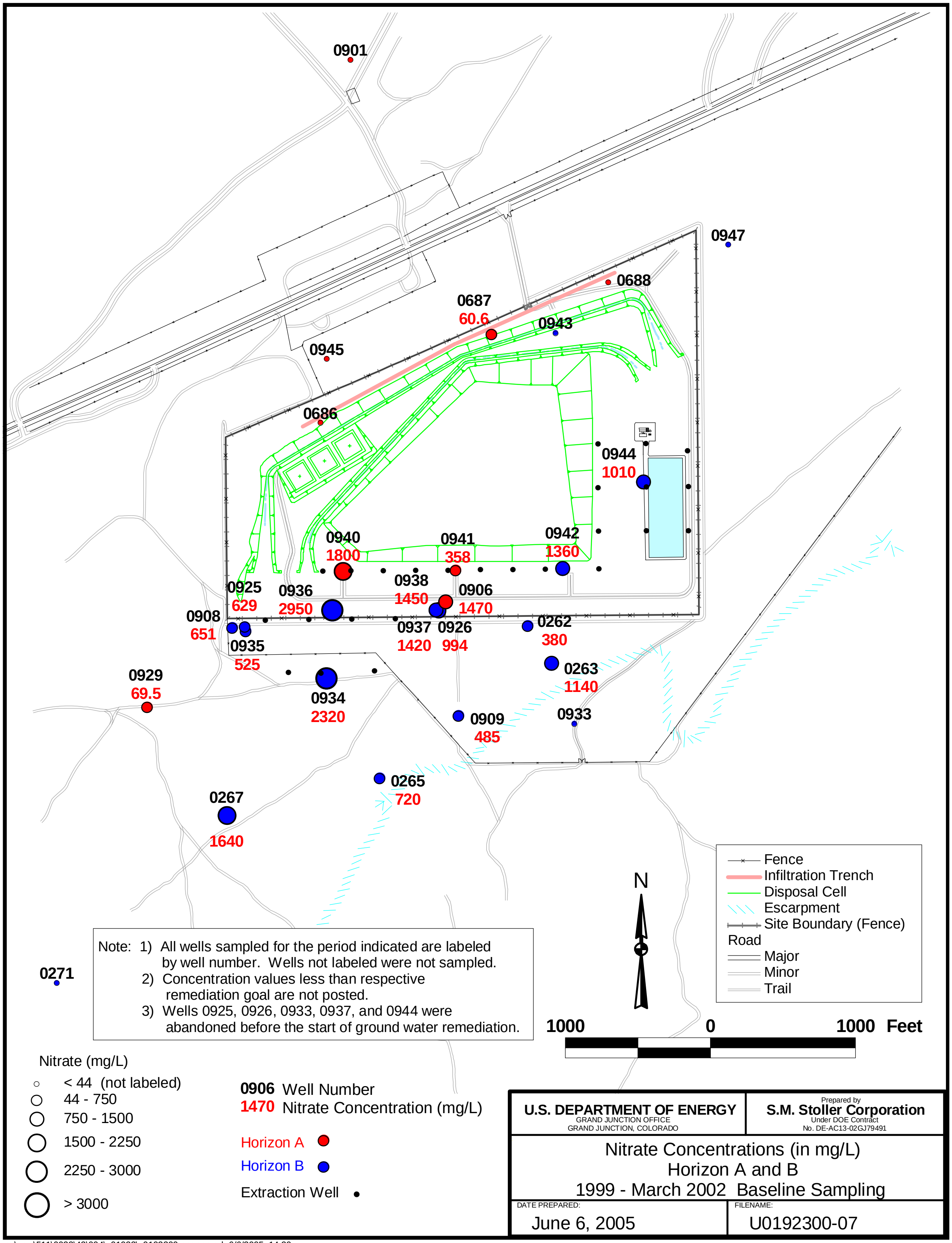

Figure 6a. Nitrate Concentrations in Ground Water, Horizons A and B, Baseline Period

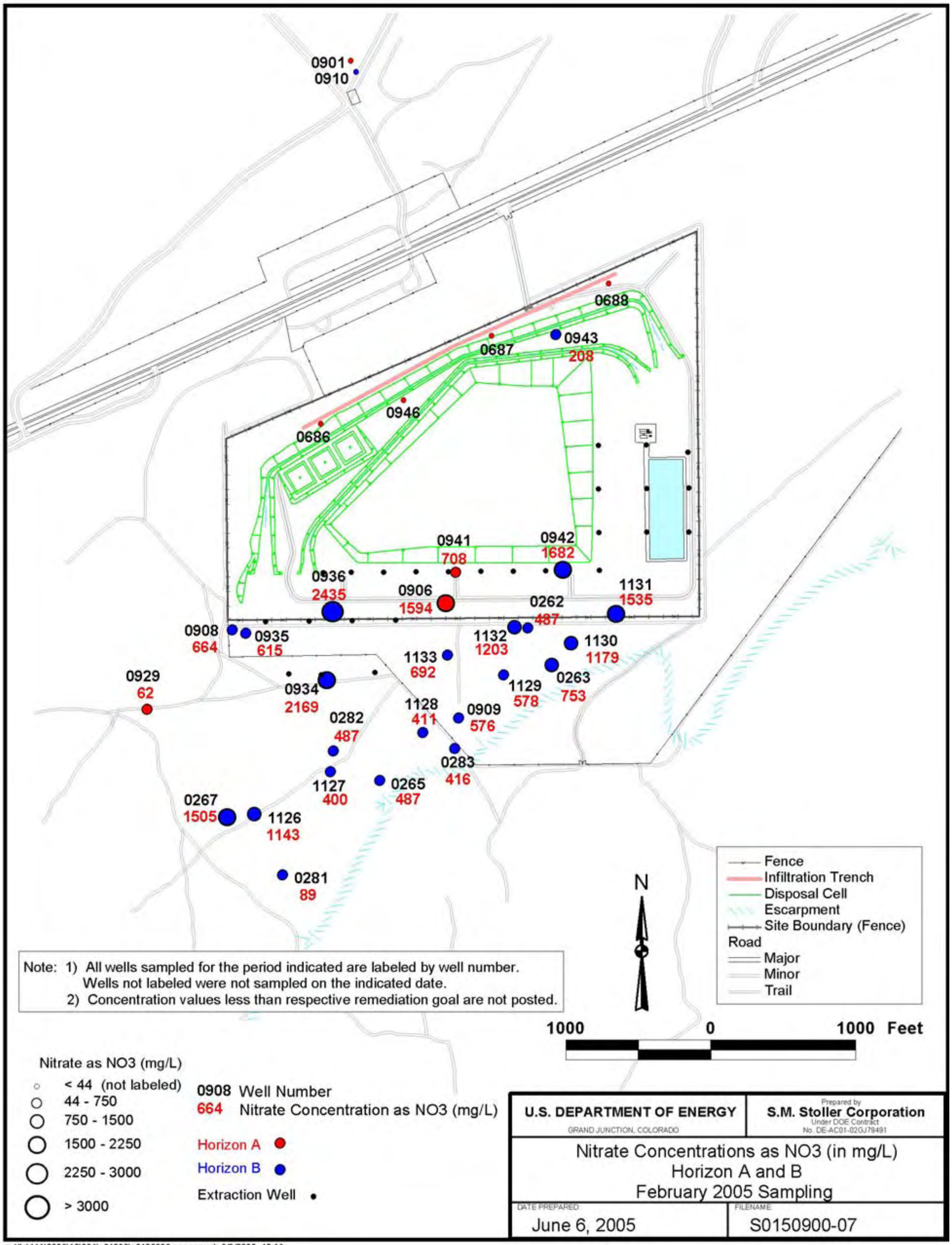

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Figure 6b. Nitrate Concentrations in Ground Water, Horizons A and B, February 2005

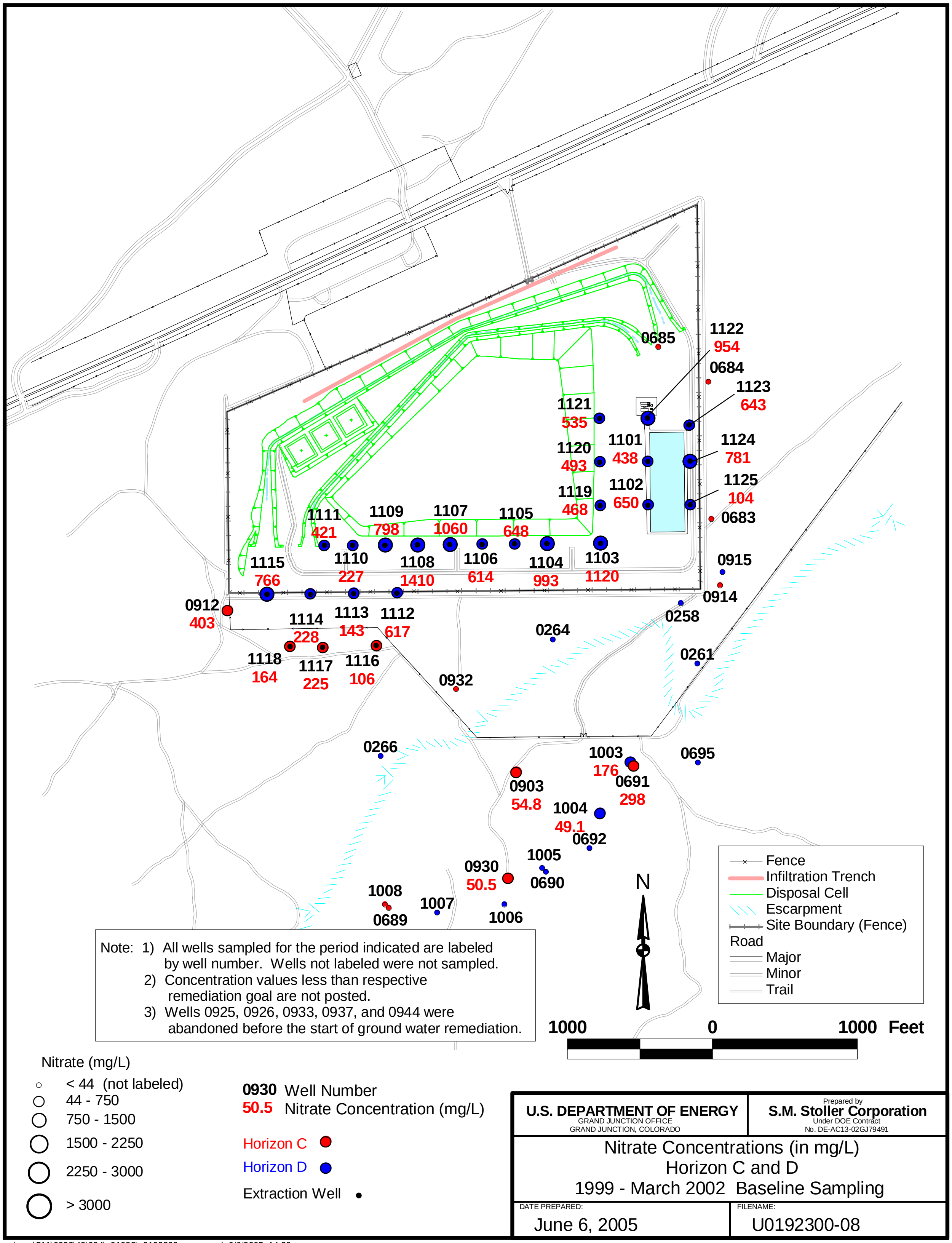

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Figure 7a. Nitrate Concentrations in Ground Water, Horizons C and D, Baseline Period

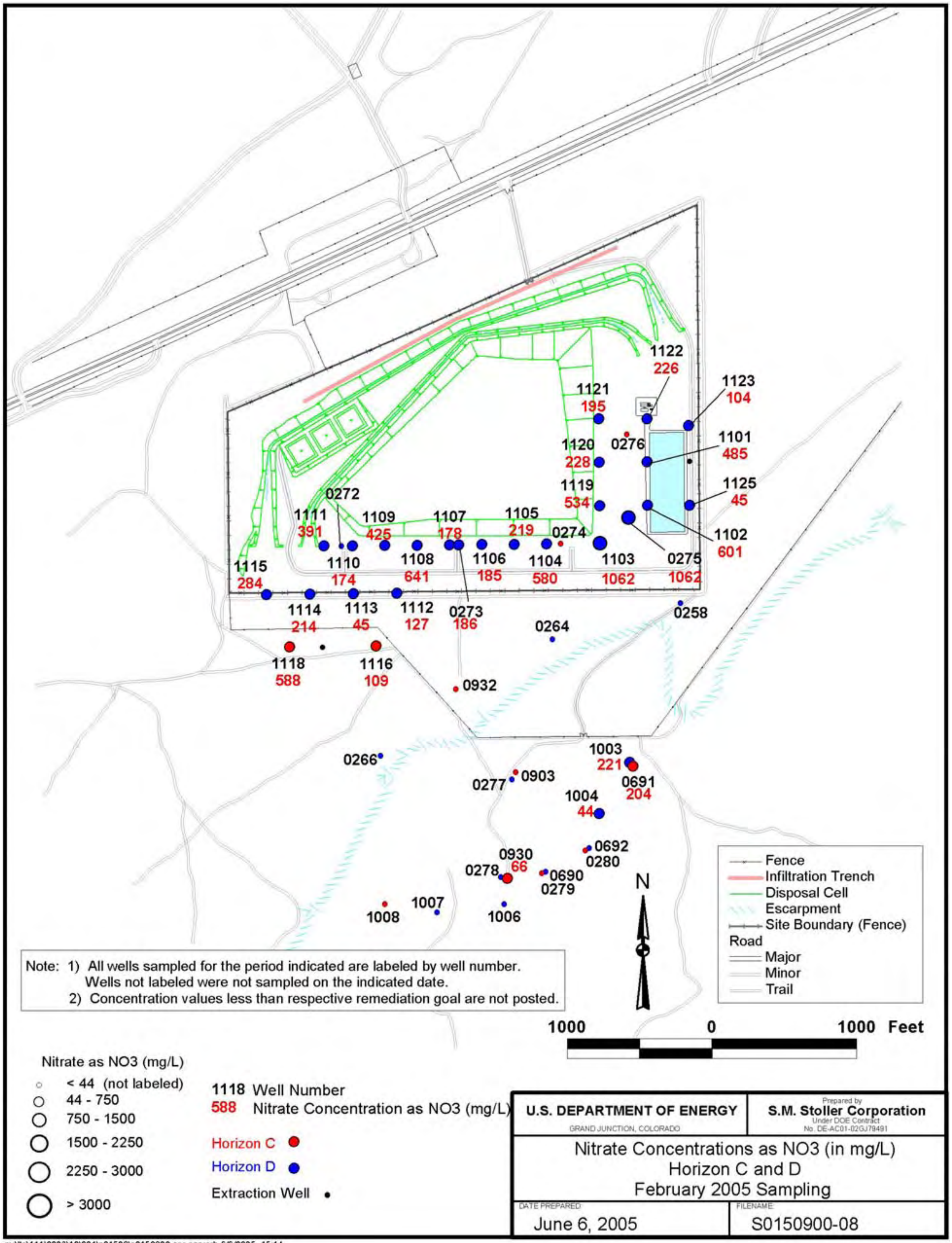

Figure 7b. Nitrate Concentrations in Ground Water, Horizons C and D, February 2005

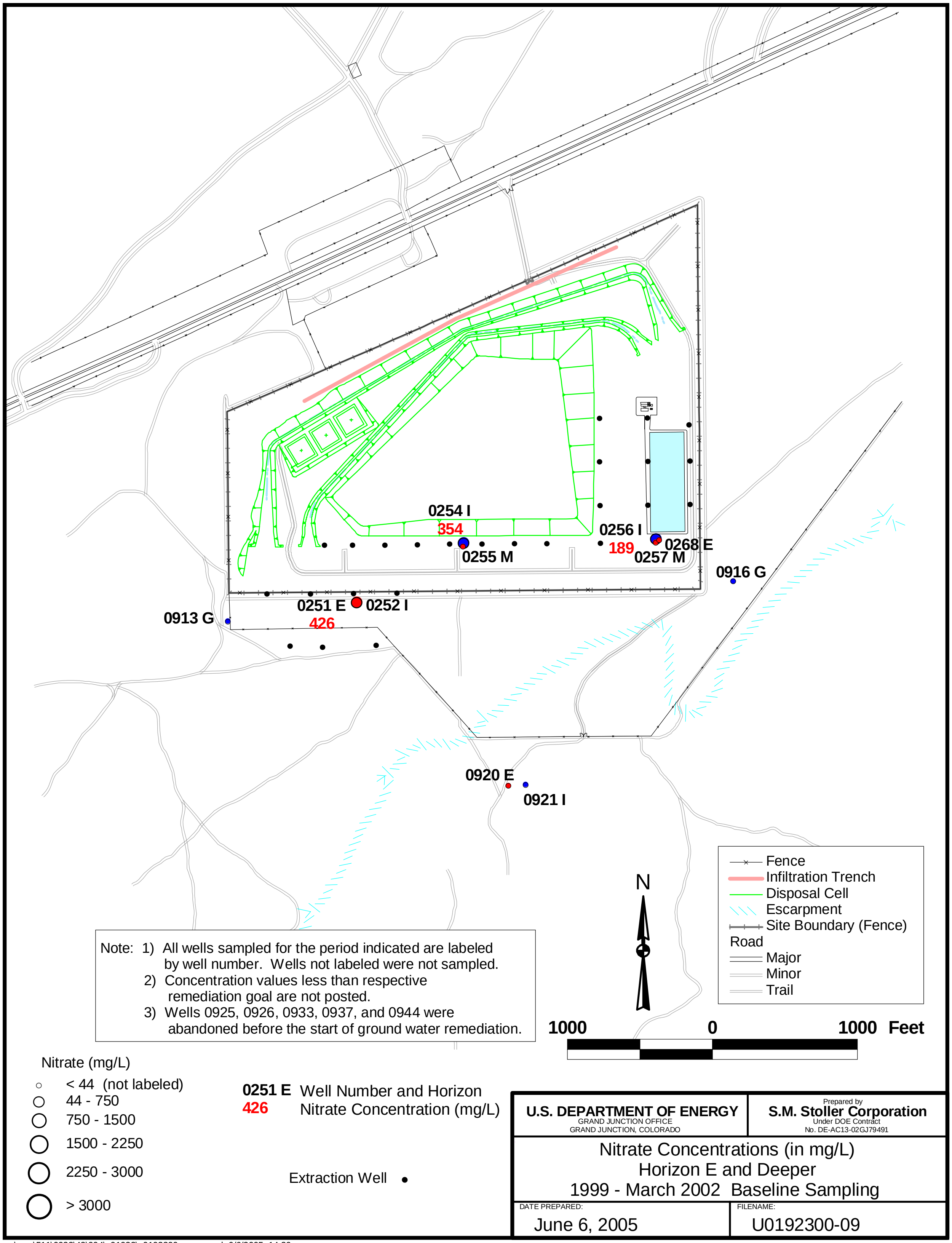

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Figure 8a. Nitrate Concentrations in Ground Water, Horizons E and Deeper, Baseline Period

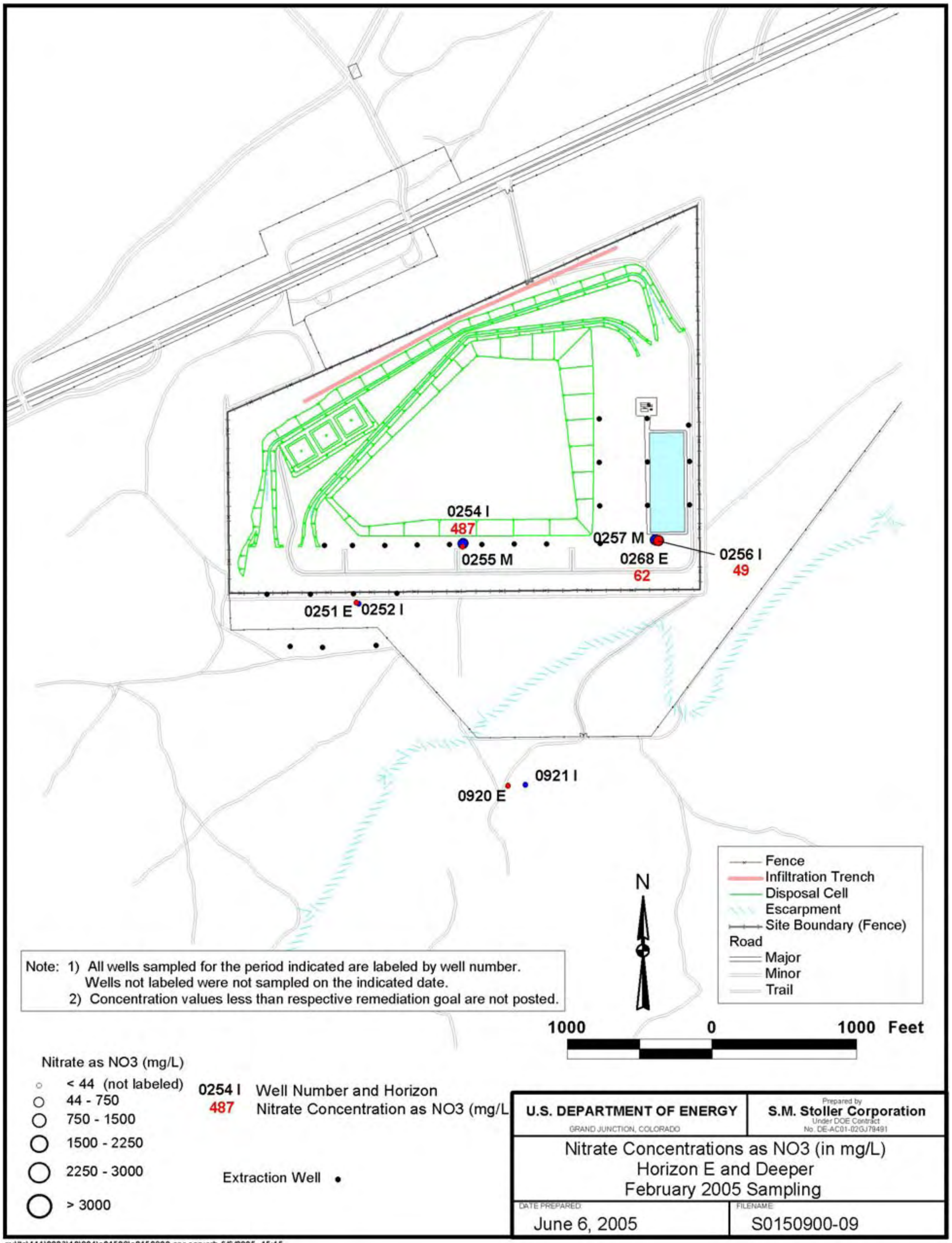

Figure 8b. Nitrate Concentrations in Ground Water, Horizons E and Deeper, February 2005

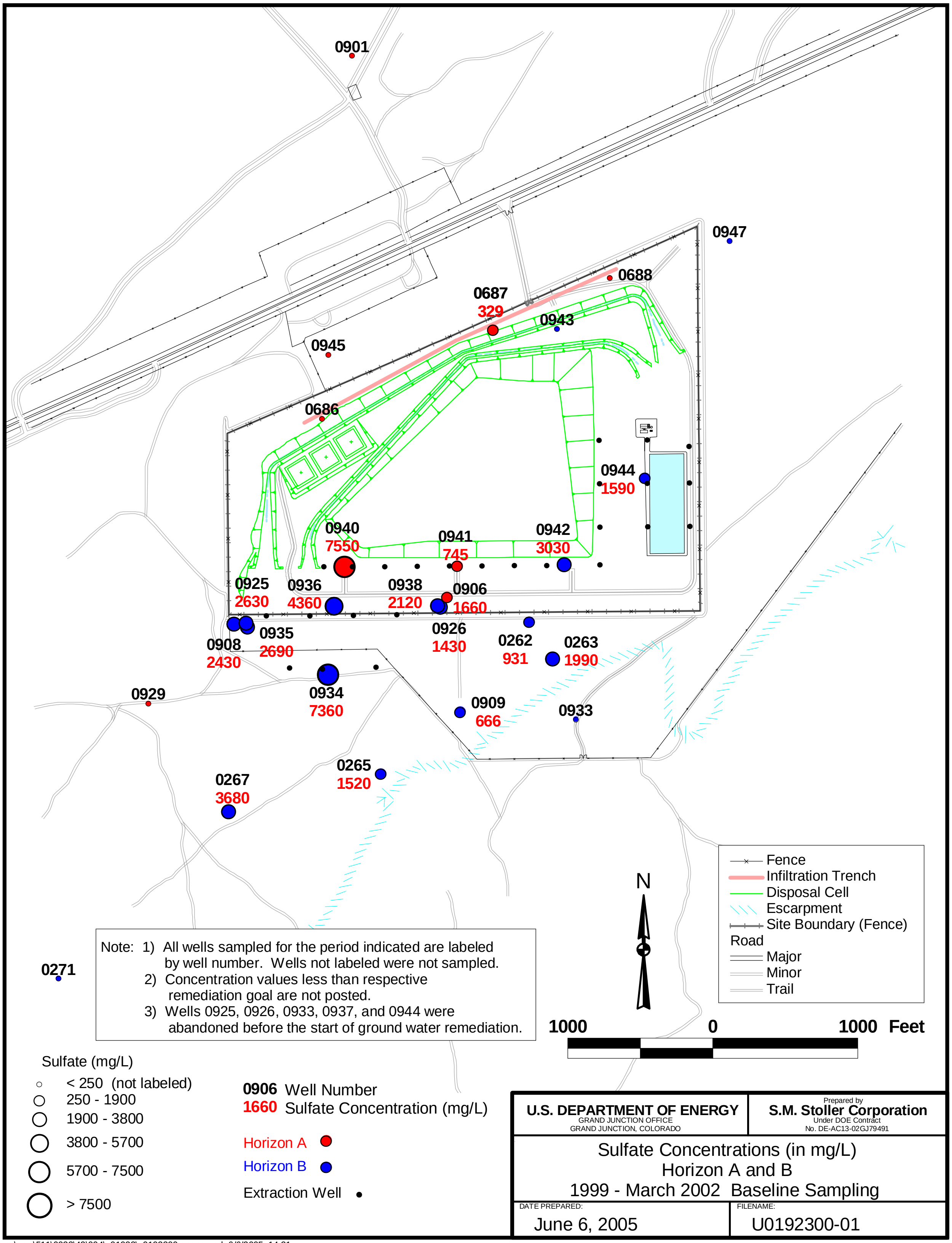

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Figure 9a. Sulfate Concentrations in Ground Water, Horizons A and B, Baseline Period

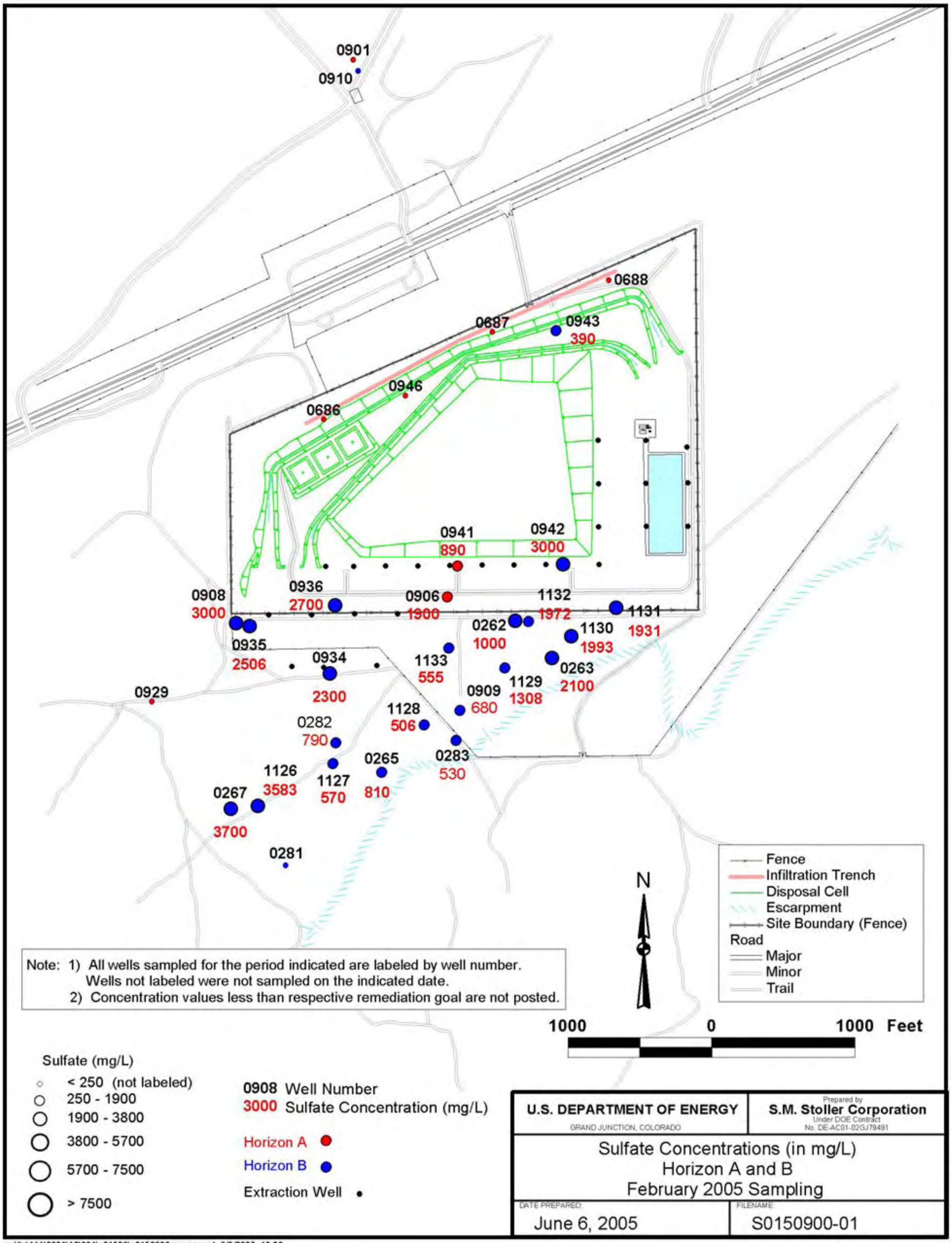

Figure 9b. Sulfate Concentrations in Ground Water, Horizons A and B, February 2005

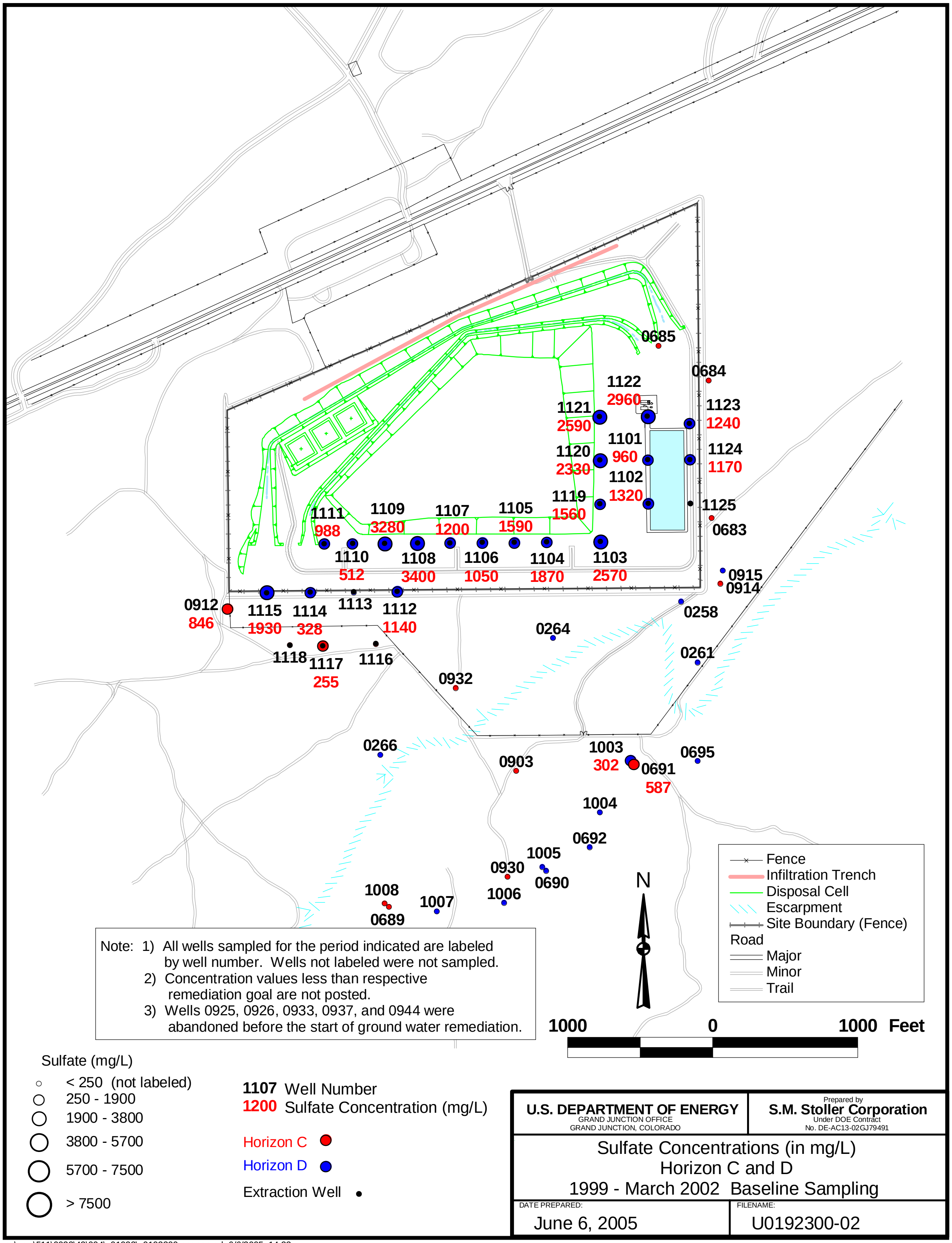

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Figure 10a. Sulfate Concentrations in Ground Water, Horizons C and D, Baseline Period

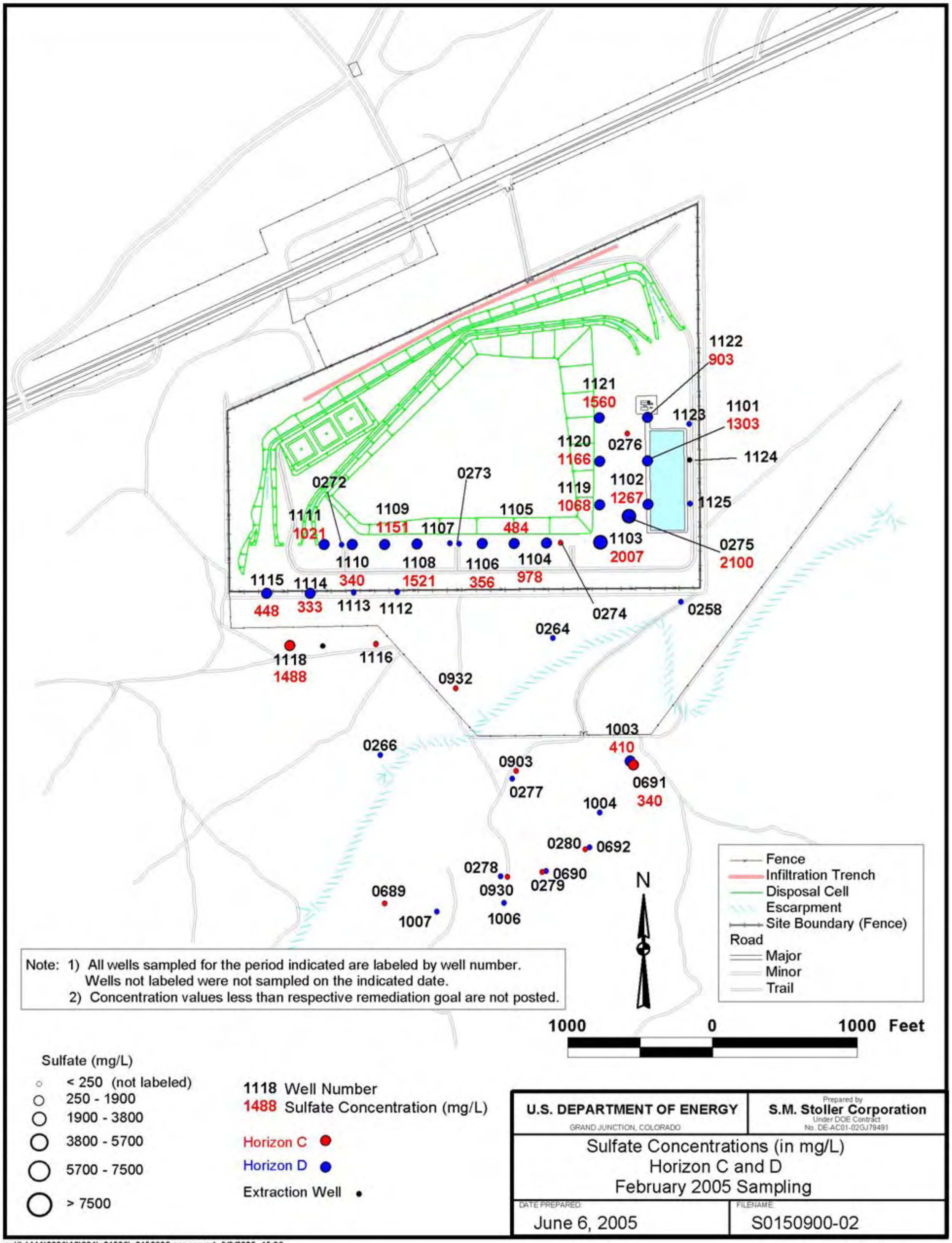

Figure 10b. Sulfate Concentrations in Ground Water, Horizons C and D, February 2005

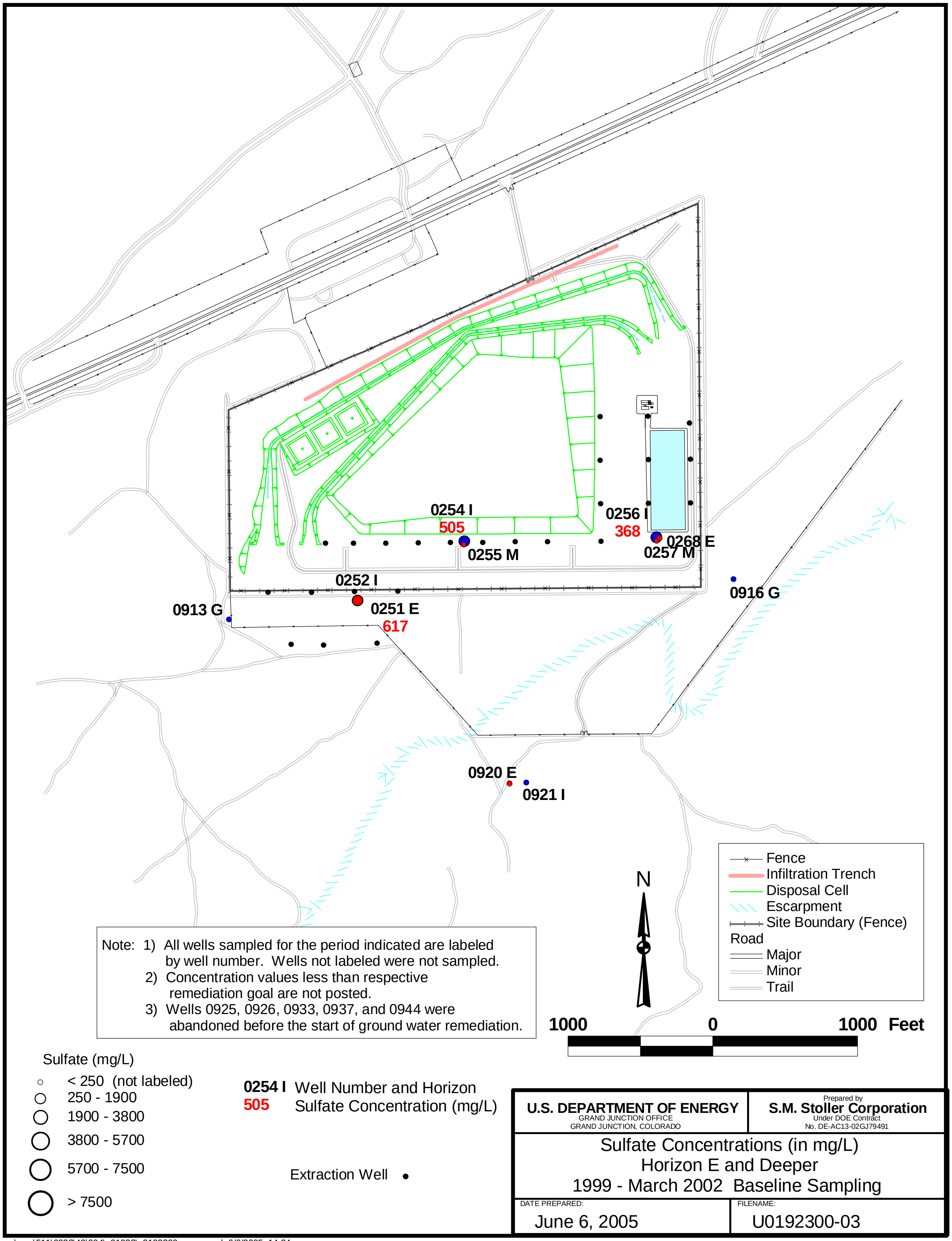

Figure 11a. Sulfate Concentrations in Ground Water, Horizons E and Deeper, Baseline Period

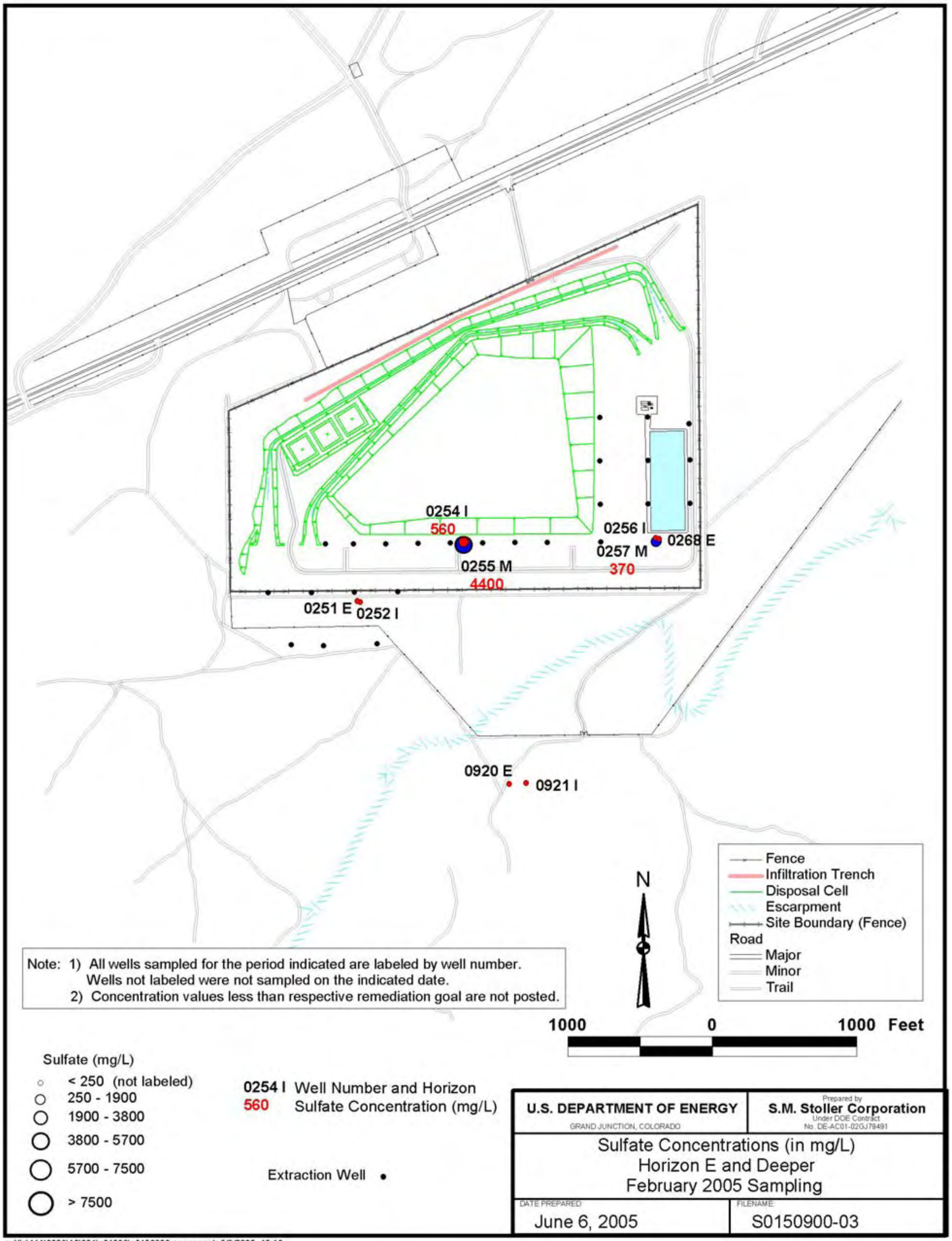

Figure 11b. Sulfate Concentrations in Ground Water, Horizons E and Deeper, February 2005

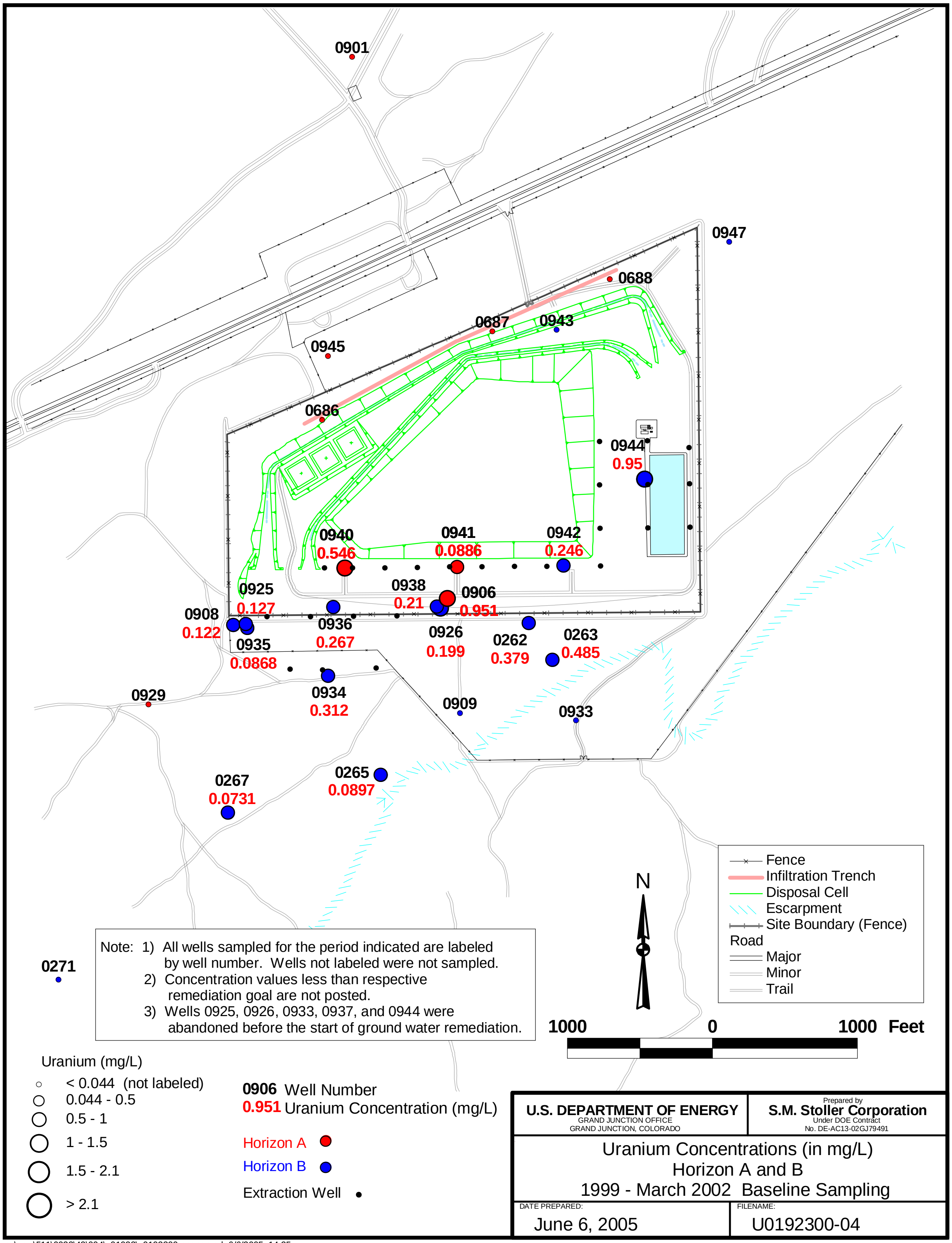

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Figure 12a. Uranium Concentrations in Ground Water, Horizons A and B, Baseline Period

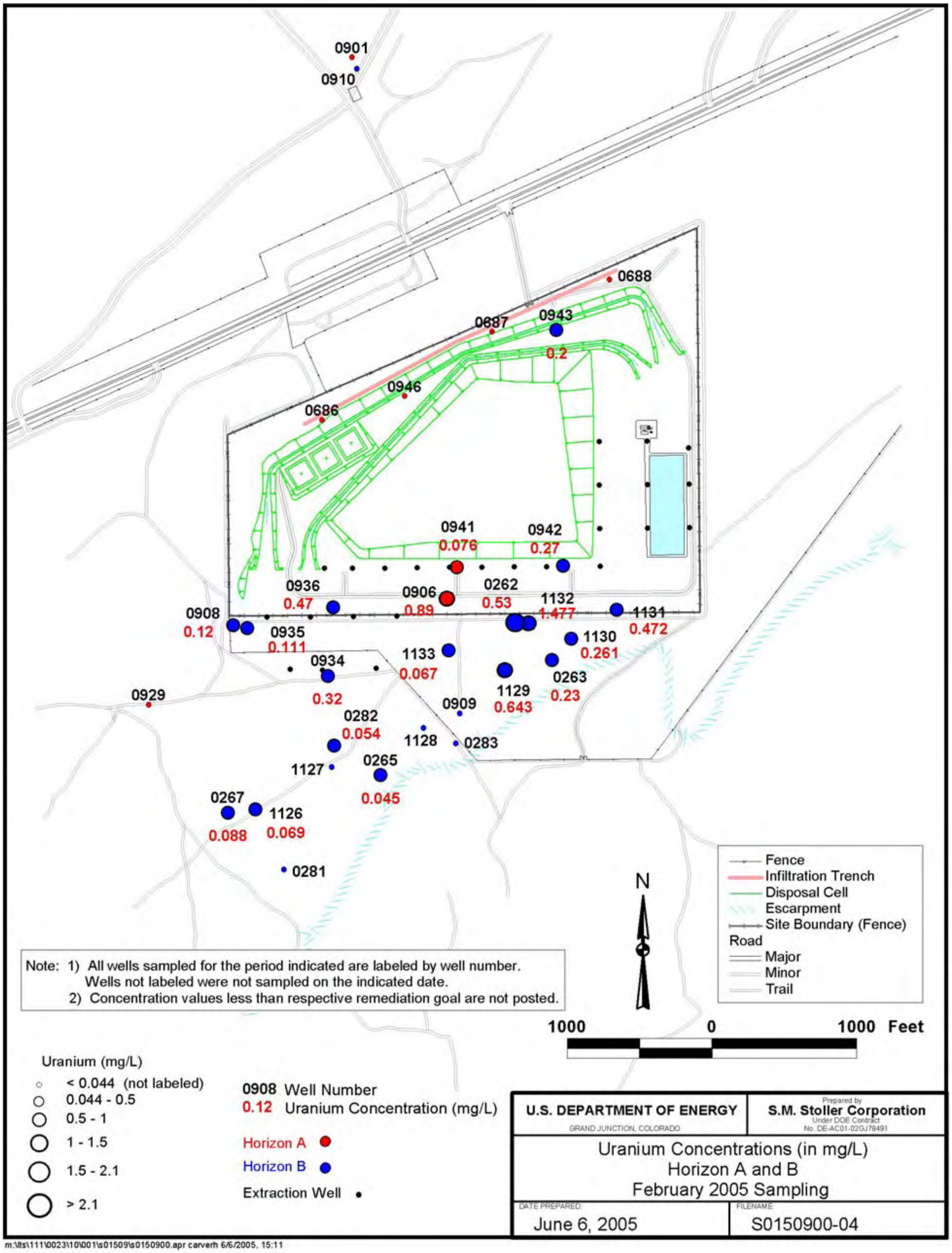

Figure 12b. Uranium Concentrations in Ground Water, Horizons A and B, February 2005

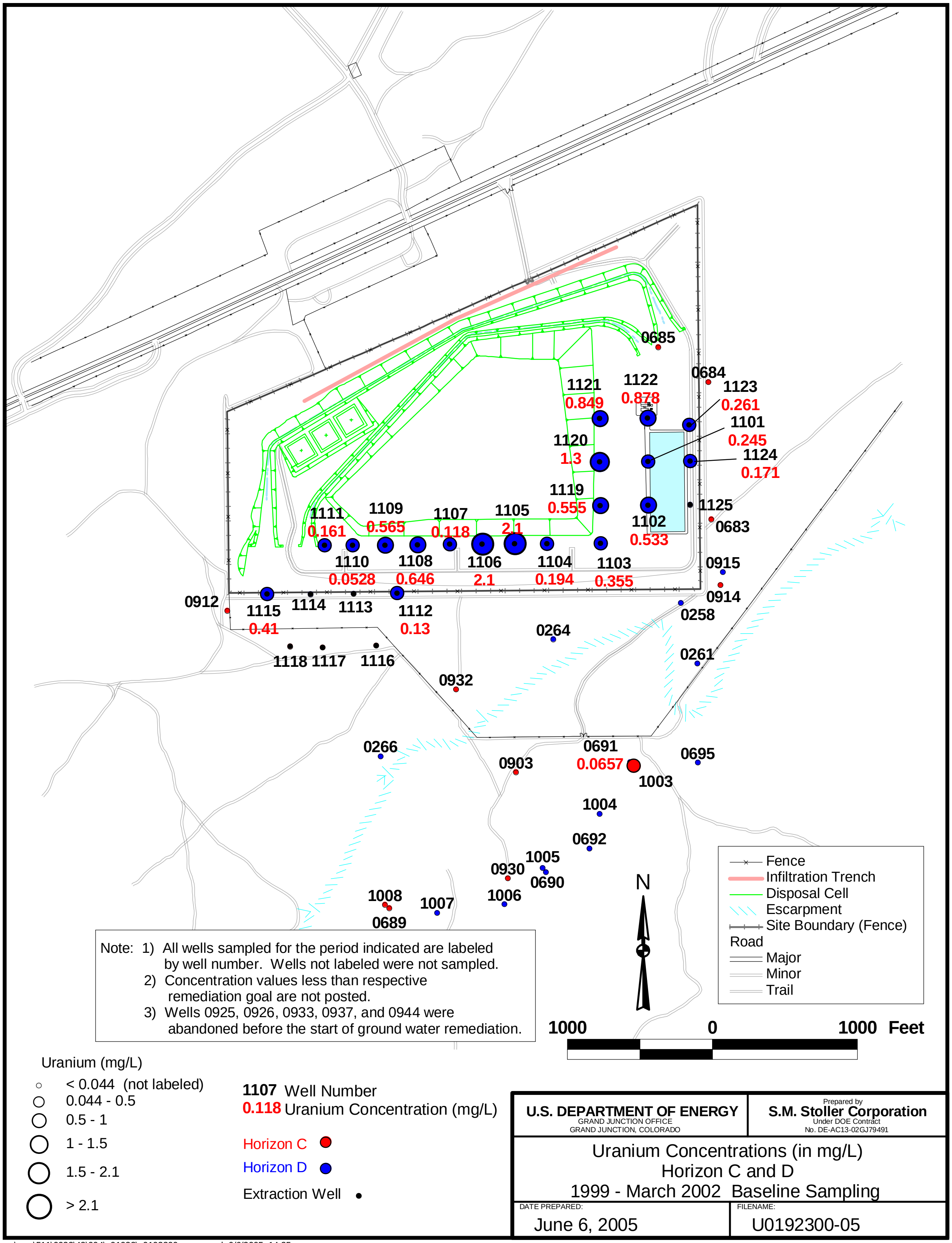

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Figure 13a. Uranium Concentrations in Ground Water, Horizons C and D, Baseline

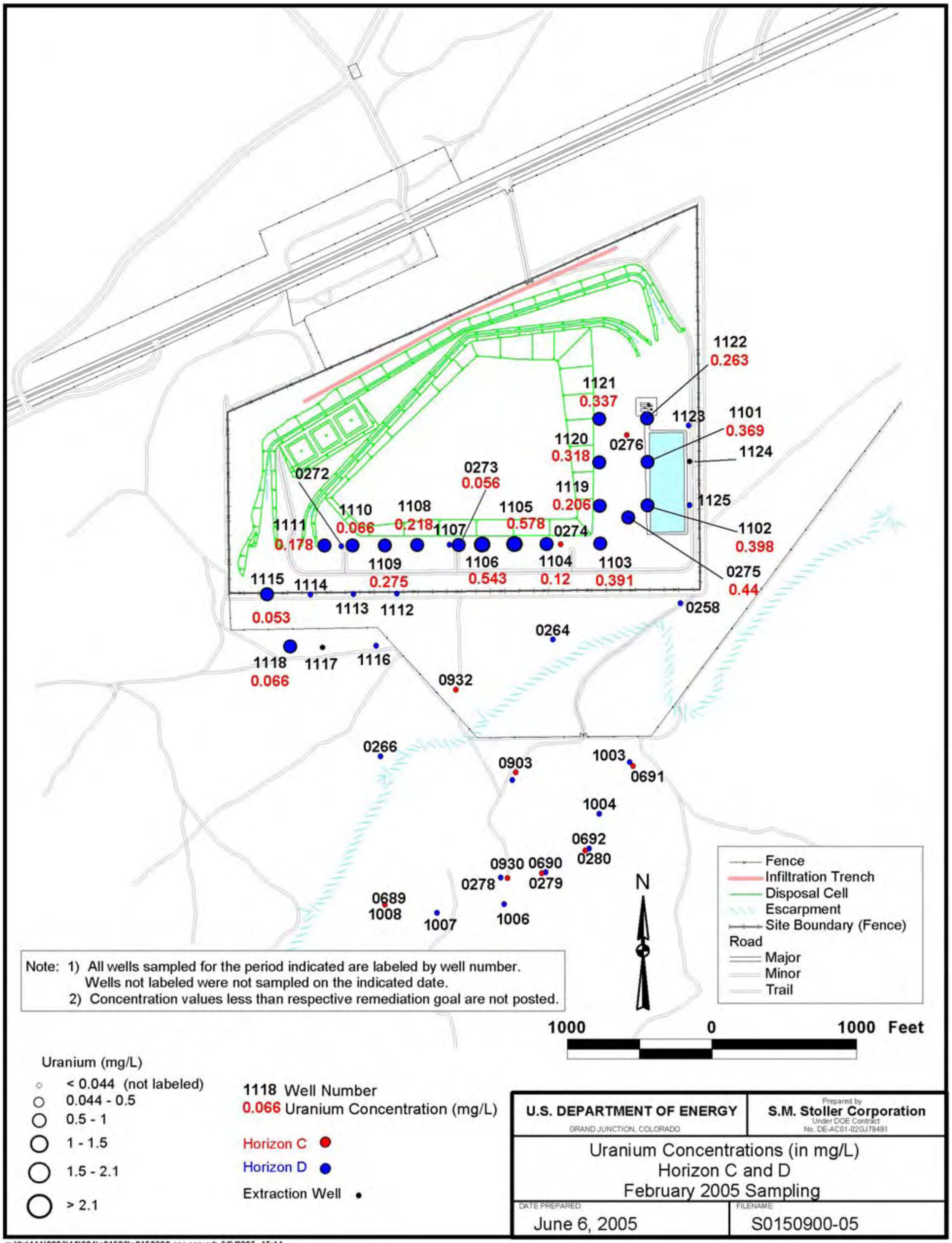

Figure 13b. Uranium Concentrations in Ground Water, Horizons C and D, February 2005

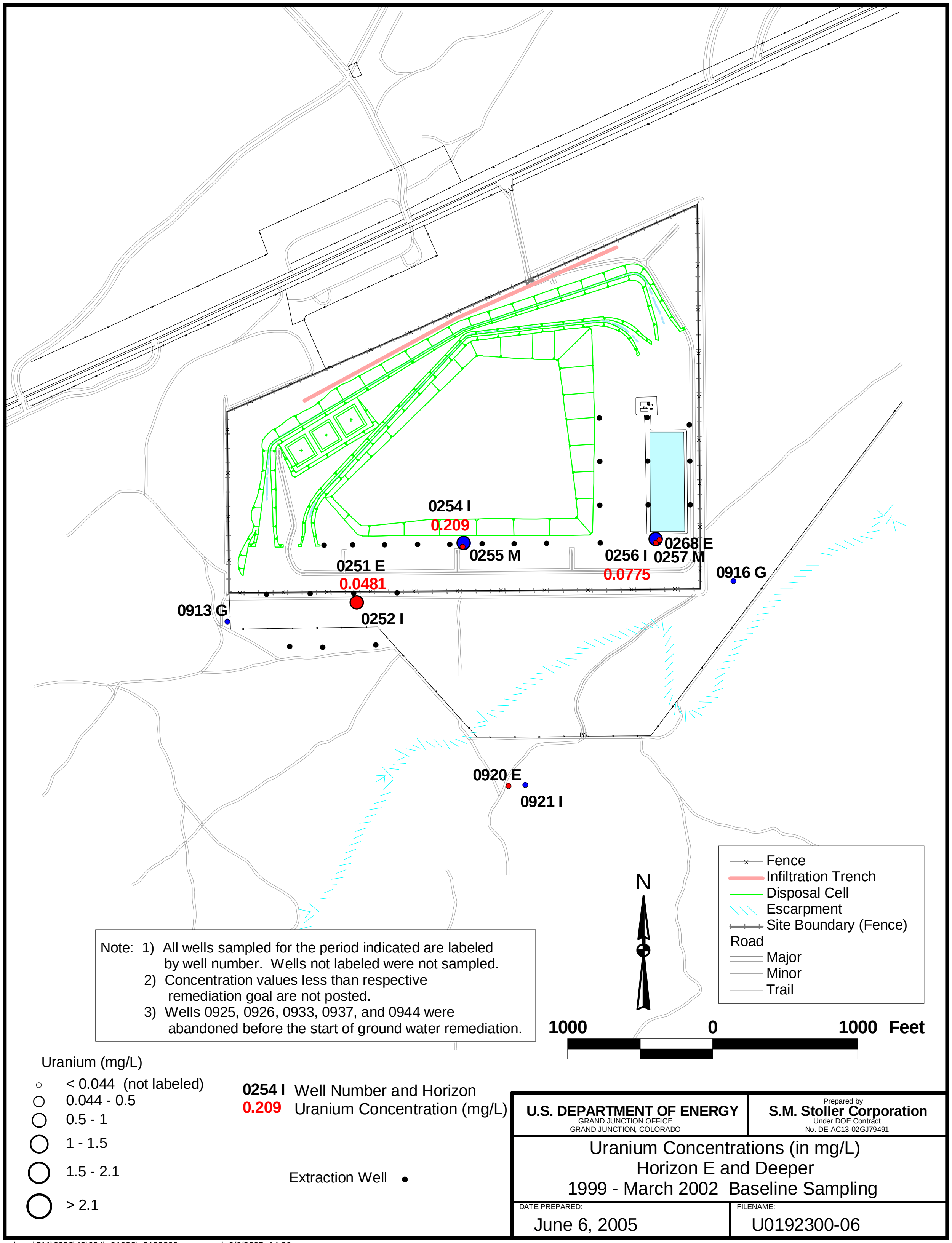

Figure 14a. Uranium Concentrations in Ground Water, Horizons E and Deeper, Baseline Period

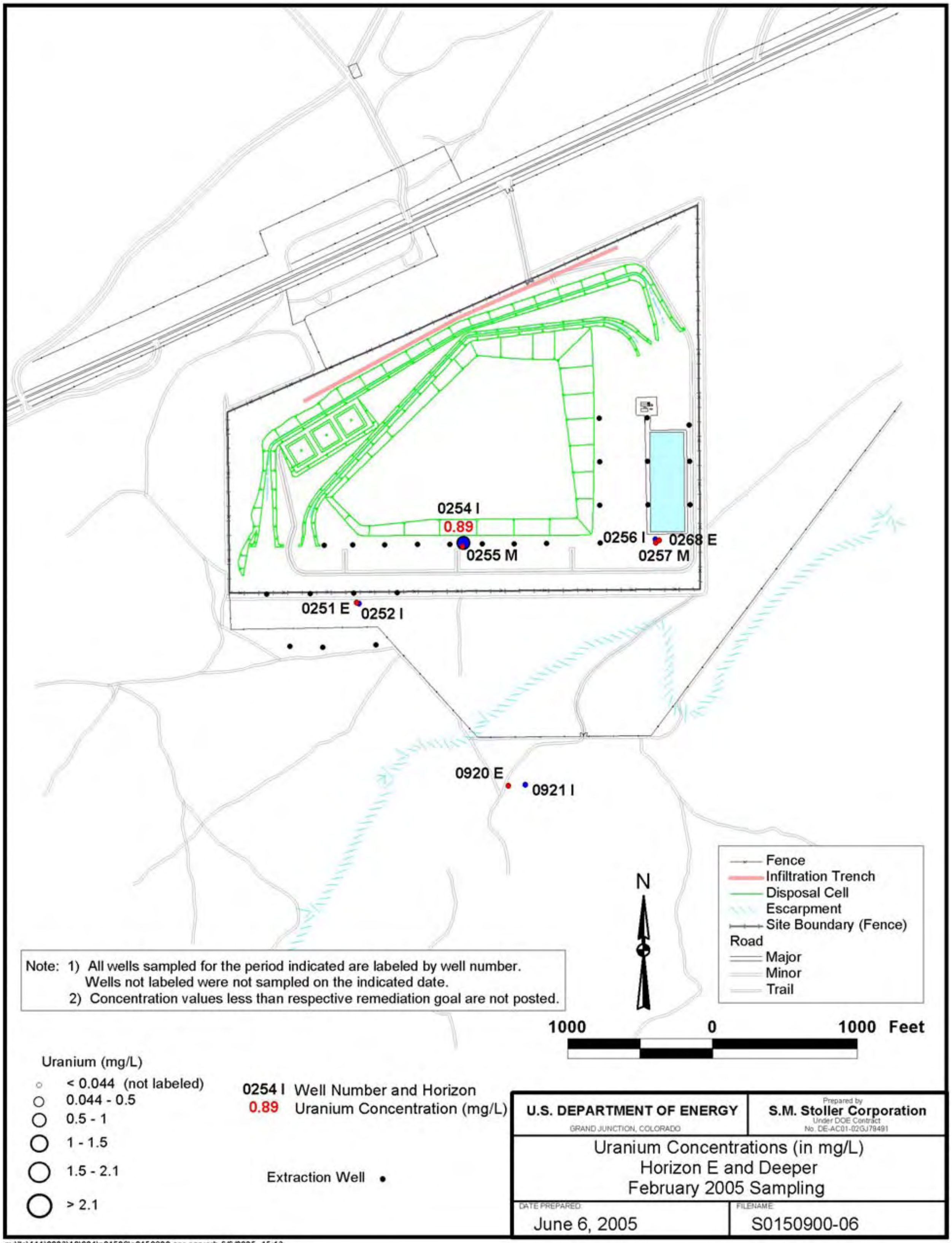

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Figure 14b. Uranium Concentrations in Ground Water, Horizons E and Deeper, February 2005

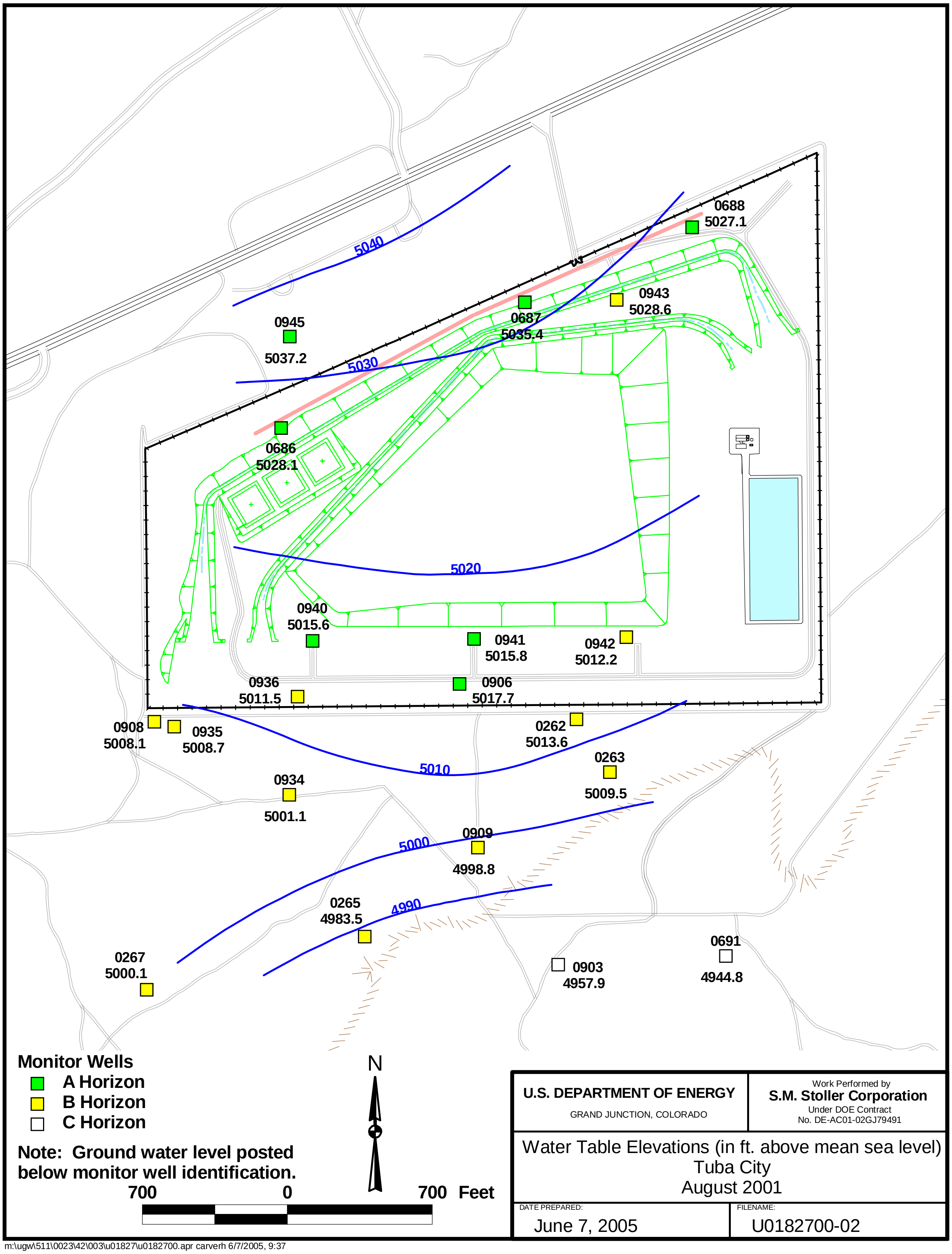

Figure 15. Water Table Elevations (in ft. above mean sea level), Tuba City Site, August 2001

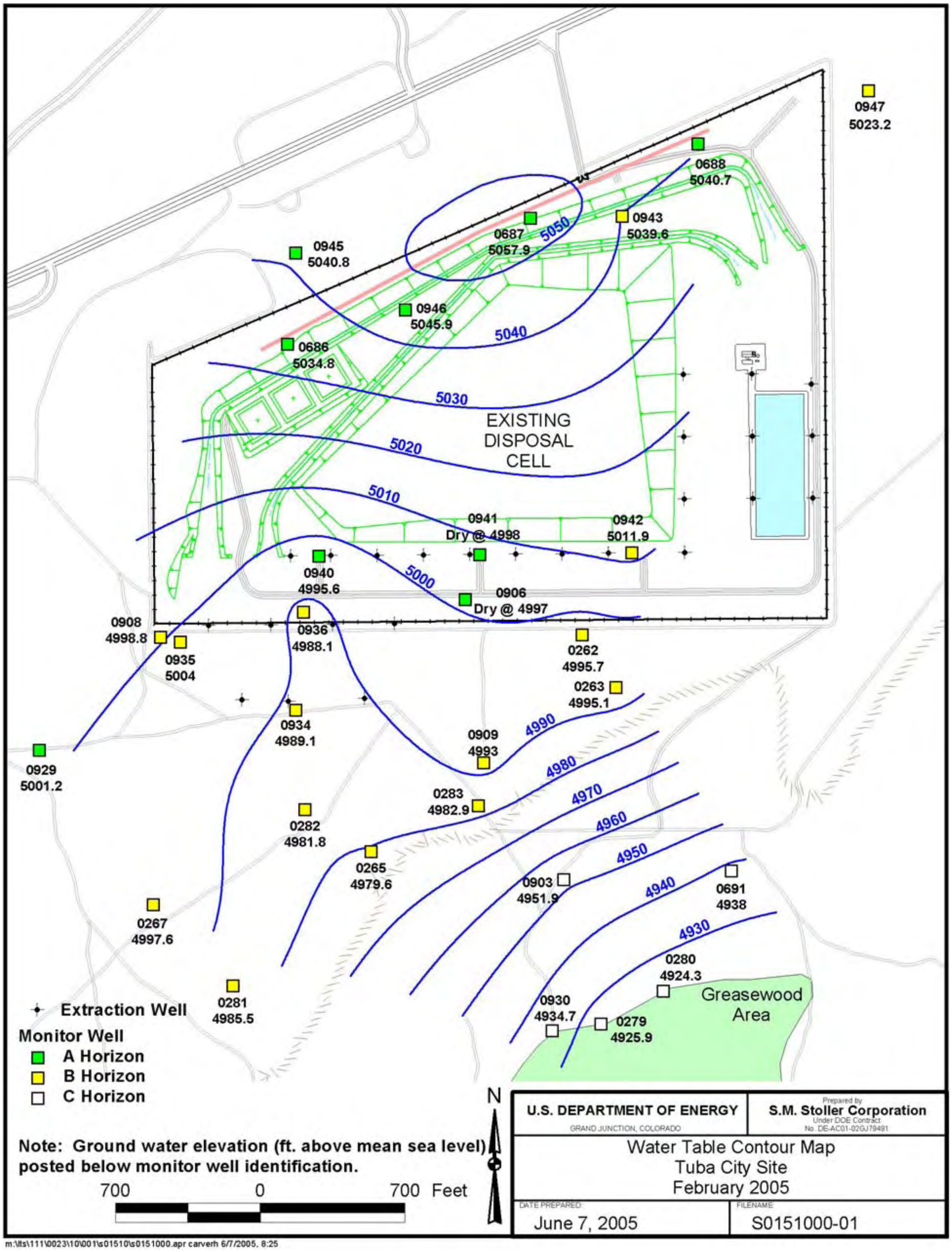

Figure 16. Water Table Contour Map, Tuba City Site, February 2005

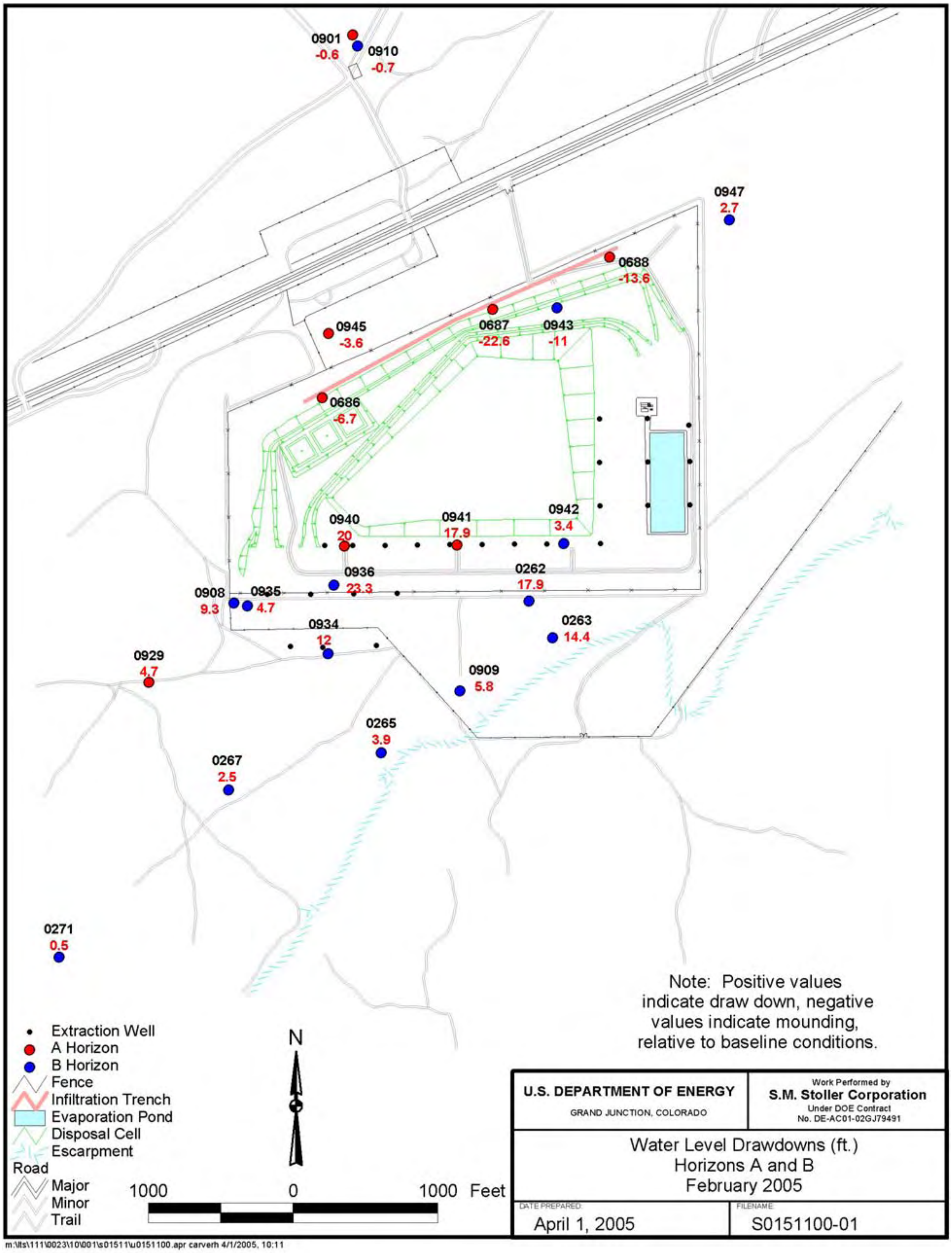

Figure 17. Water Level Drawdowns (ft), Horizons A and B, February 2005

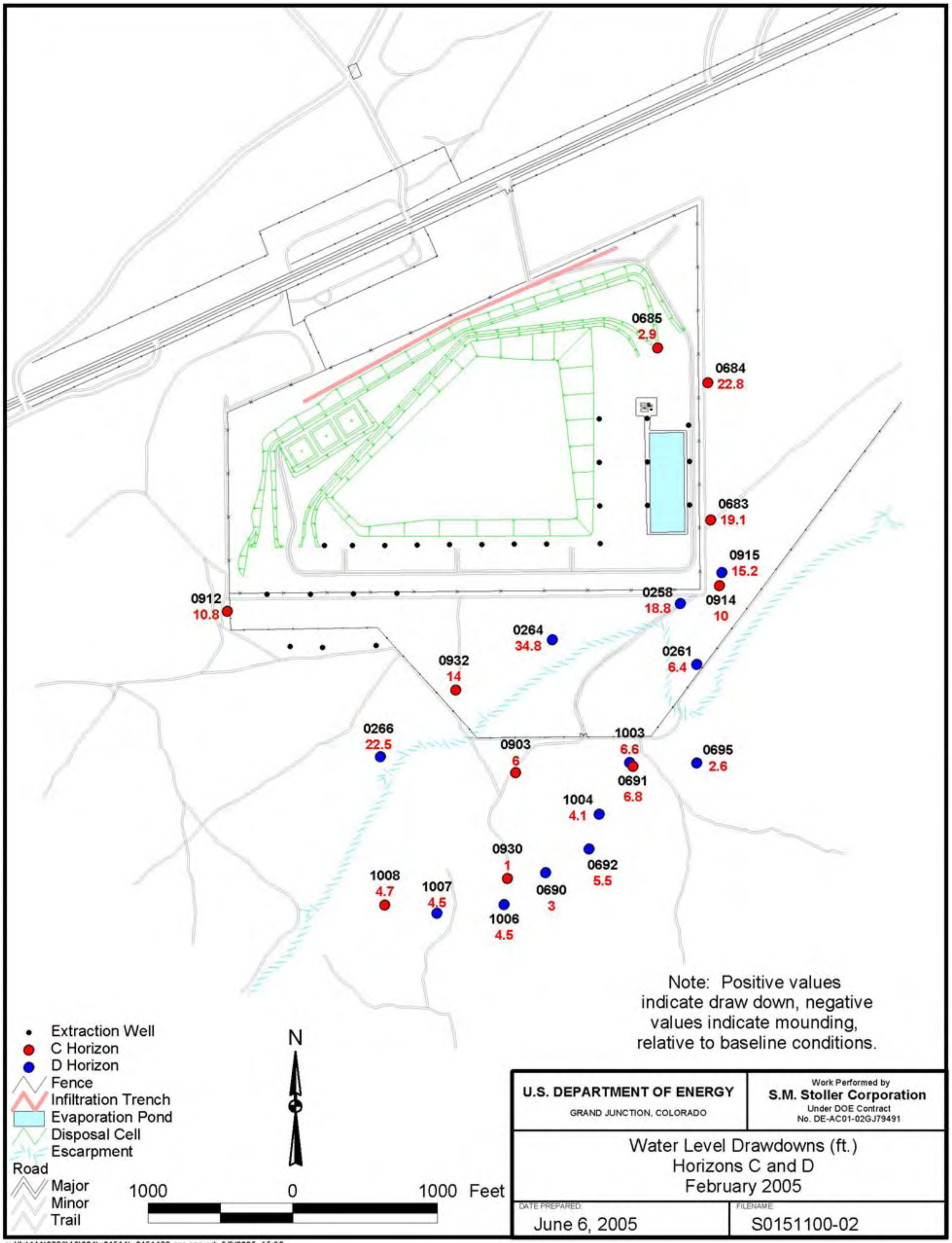

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Figure 18. Water Level Drawdowns (ft), Horizons C and D, February 2005

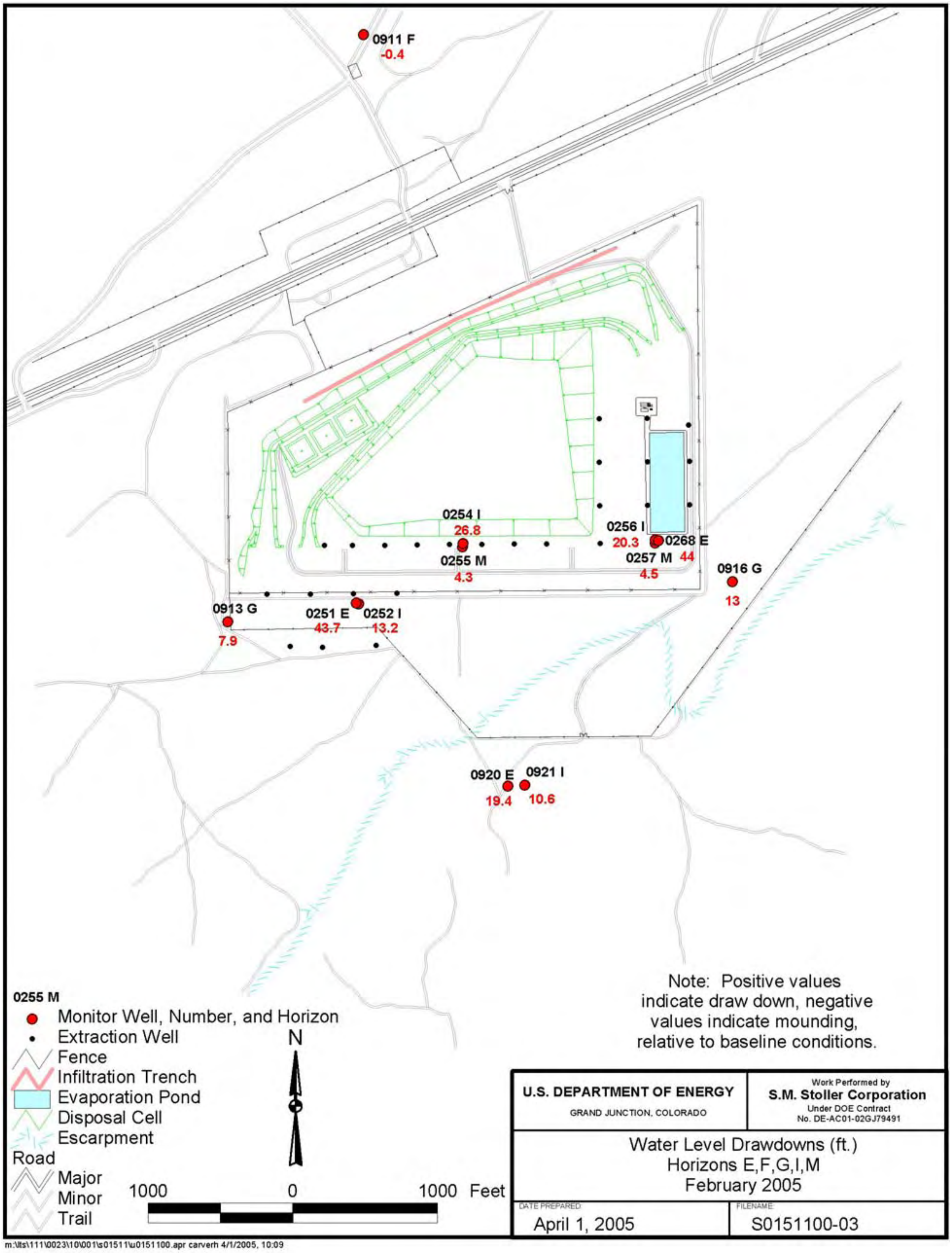

Figure 19. Water Level Drawdowns (ft), Horizons E, F, G, I, and M, February 2005

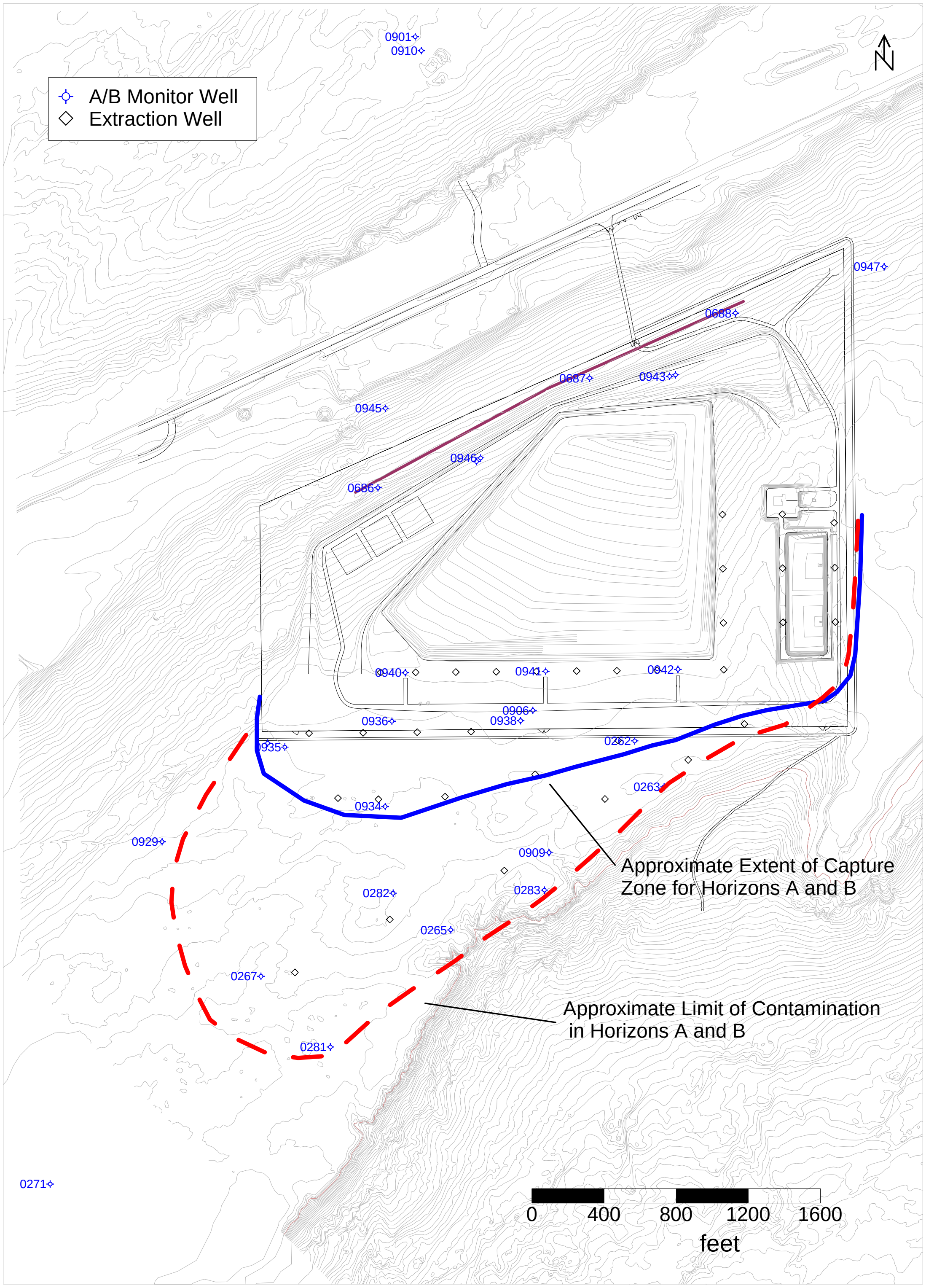

Figure 20. Extent of Ground Water Contamination and Extraction System Capture Zone: Horizons A and B

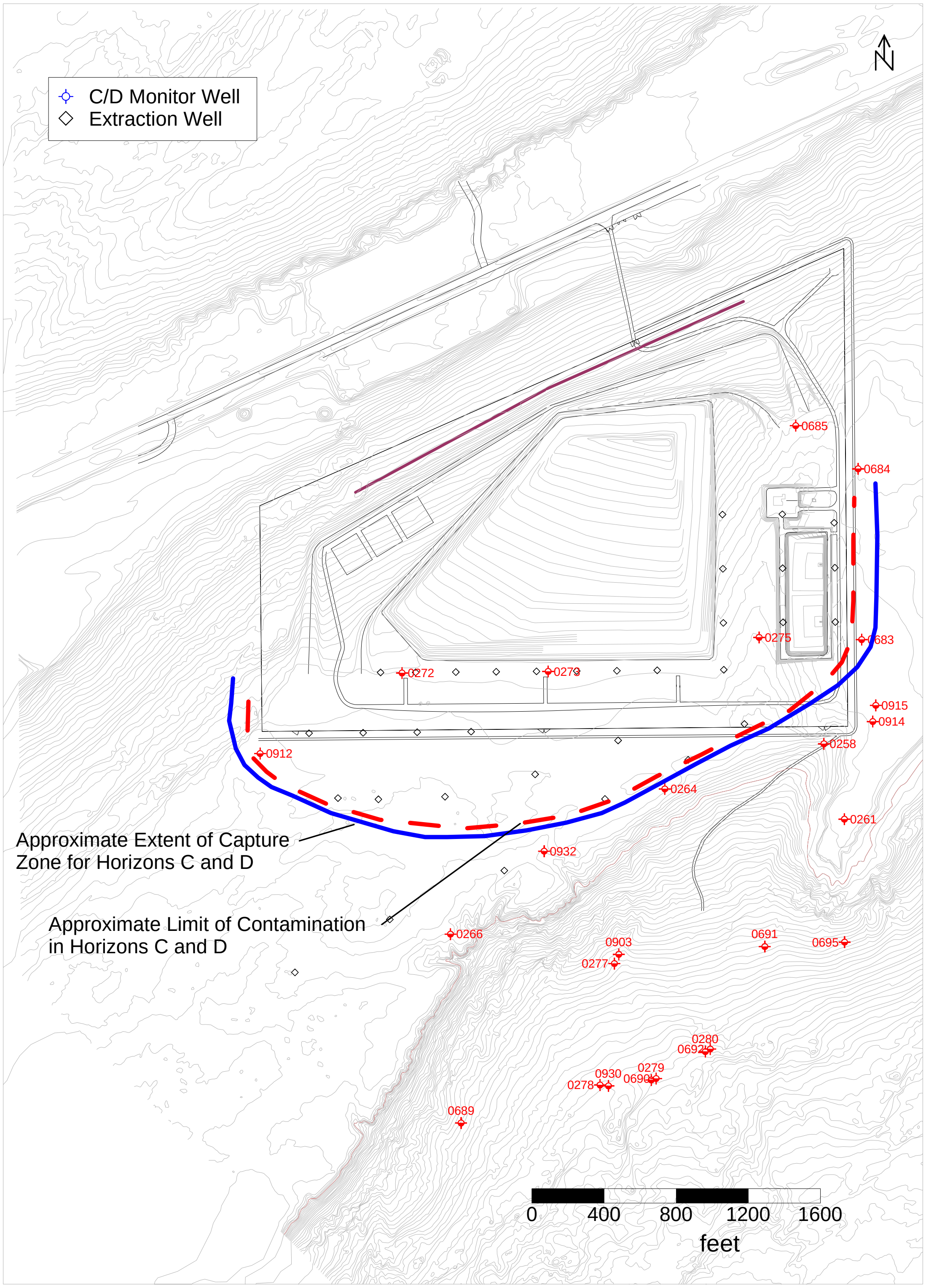

Figure 21. Extent of Ground Water Contamination and Extraction System Capture Zone: Horizons C and D

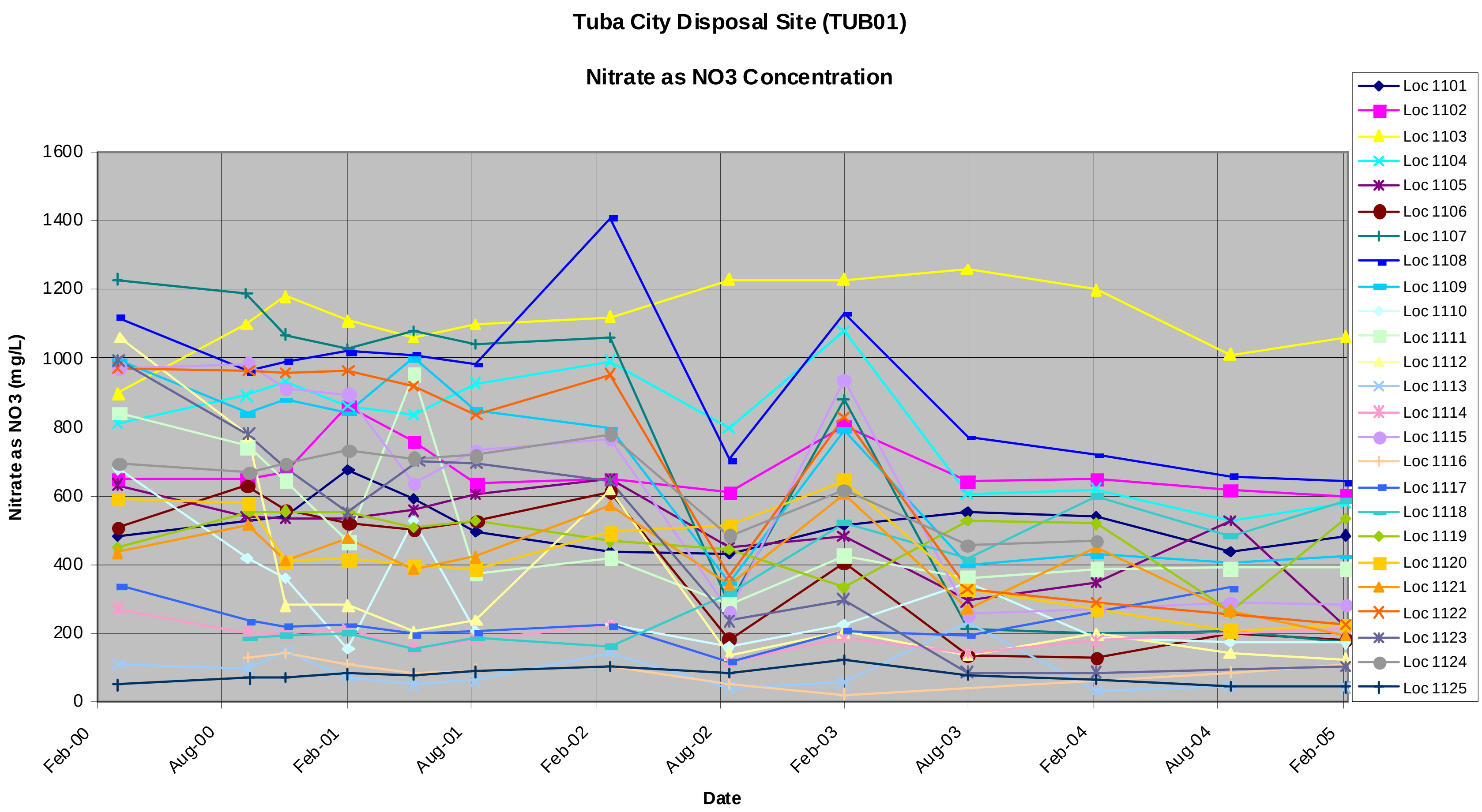

Figure 22. Nitrate Concentration Trends at Extraction Wells

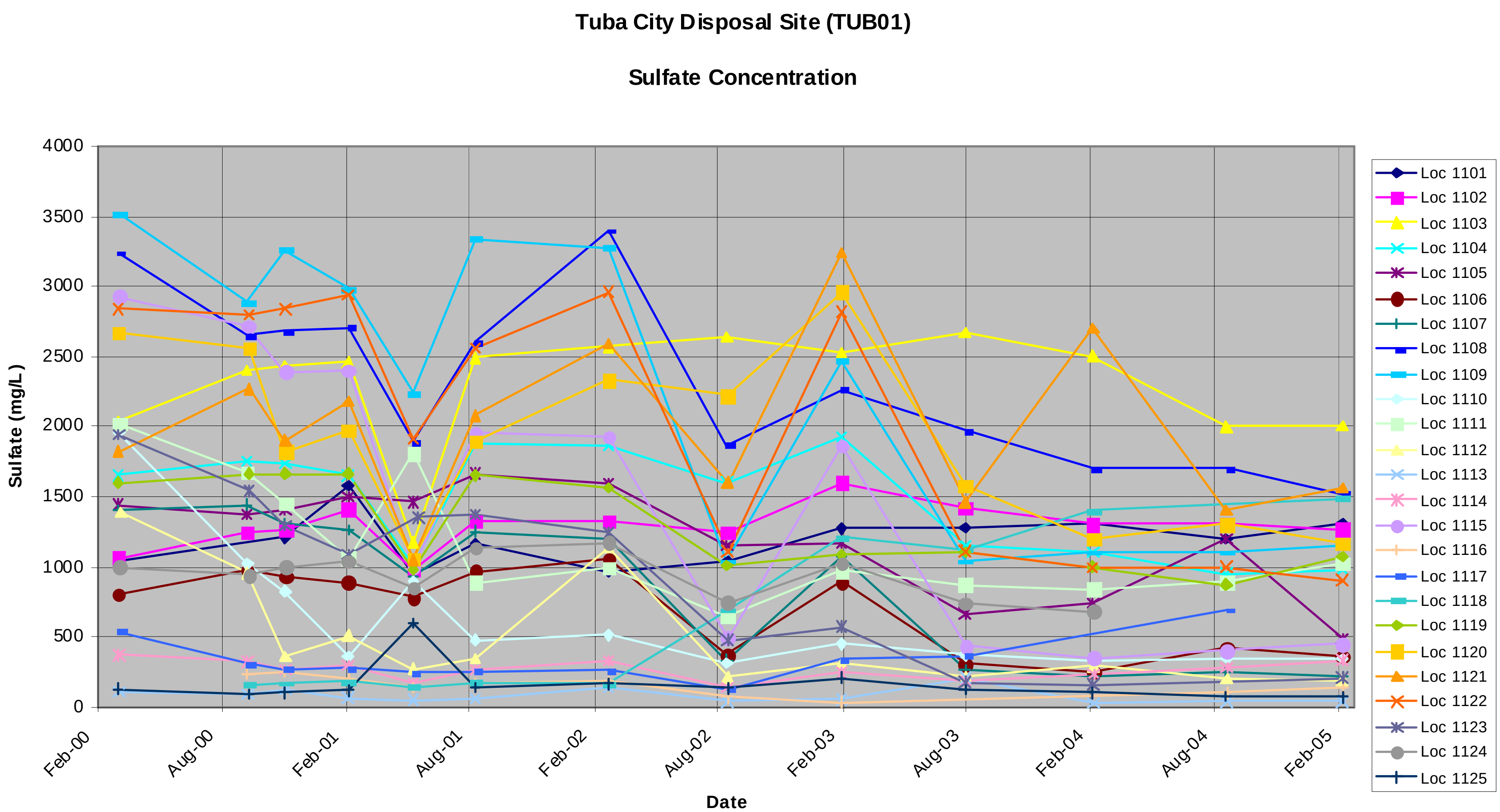

Figure 23. Sulfate Concentration Trends at Extraction Wells

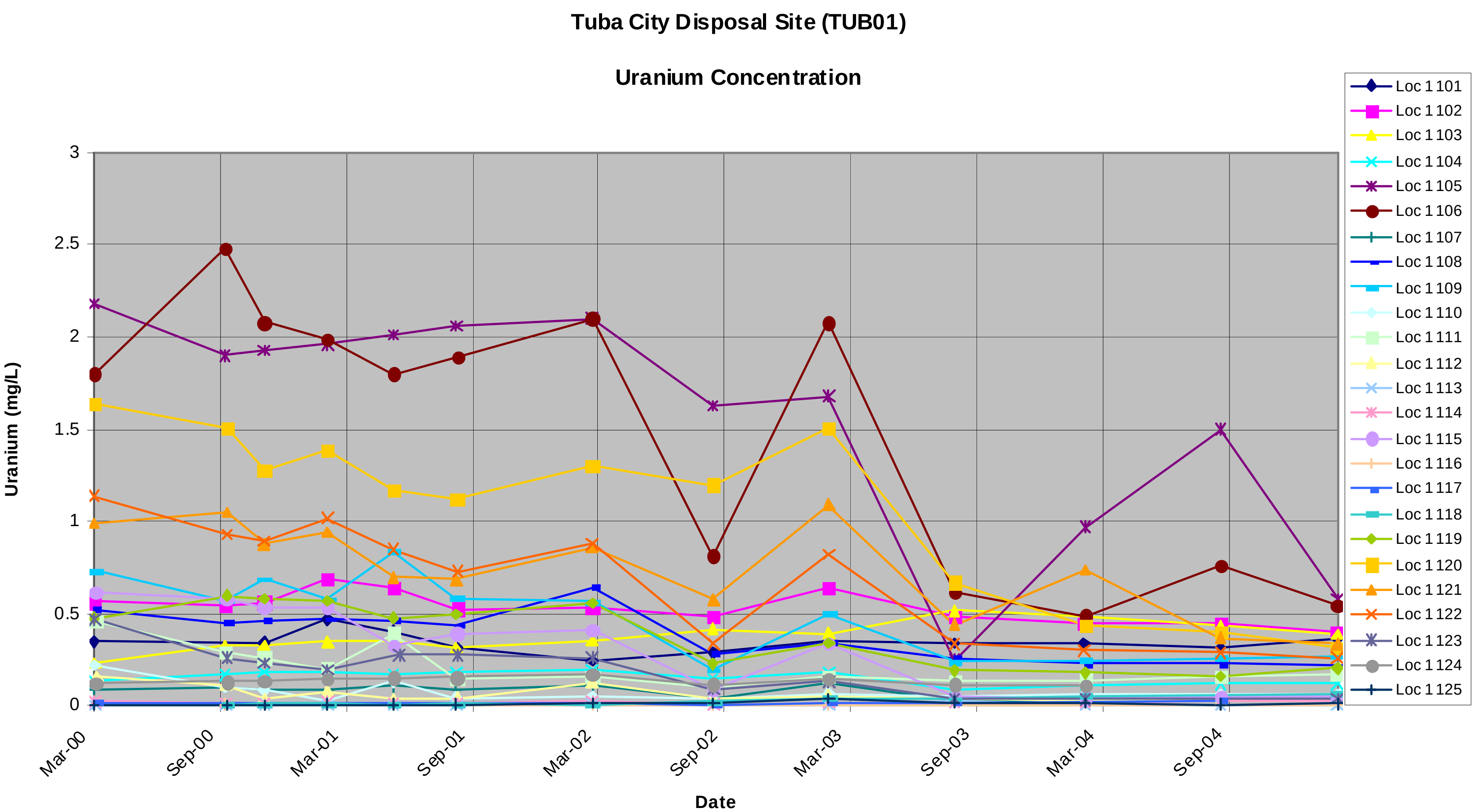

Figure 24. Uranium Concentration Trends at Extraction Wells

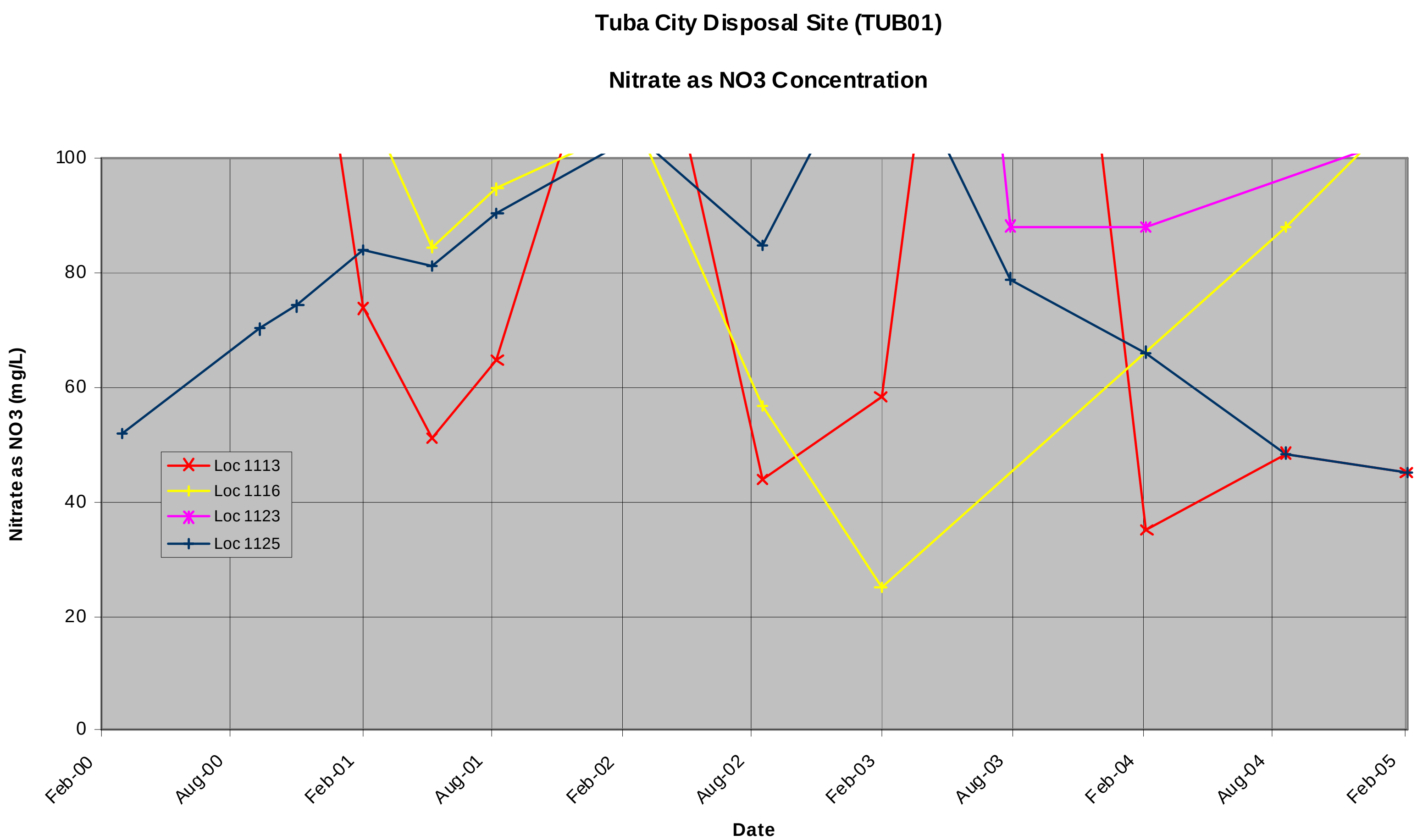

Figure 25. Nitrate Concentrations Trends Near Remediation Standard (44 mg/L as NO_3) at Extraction Wells

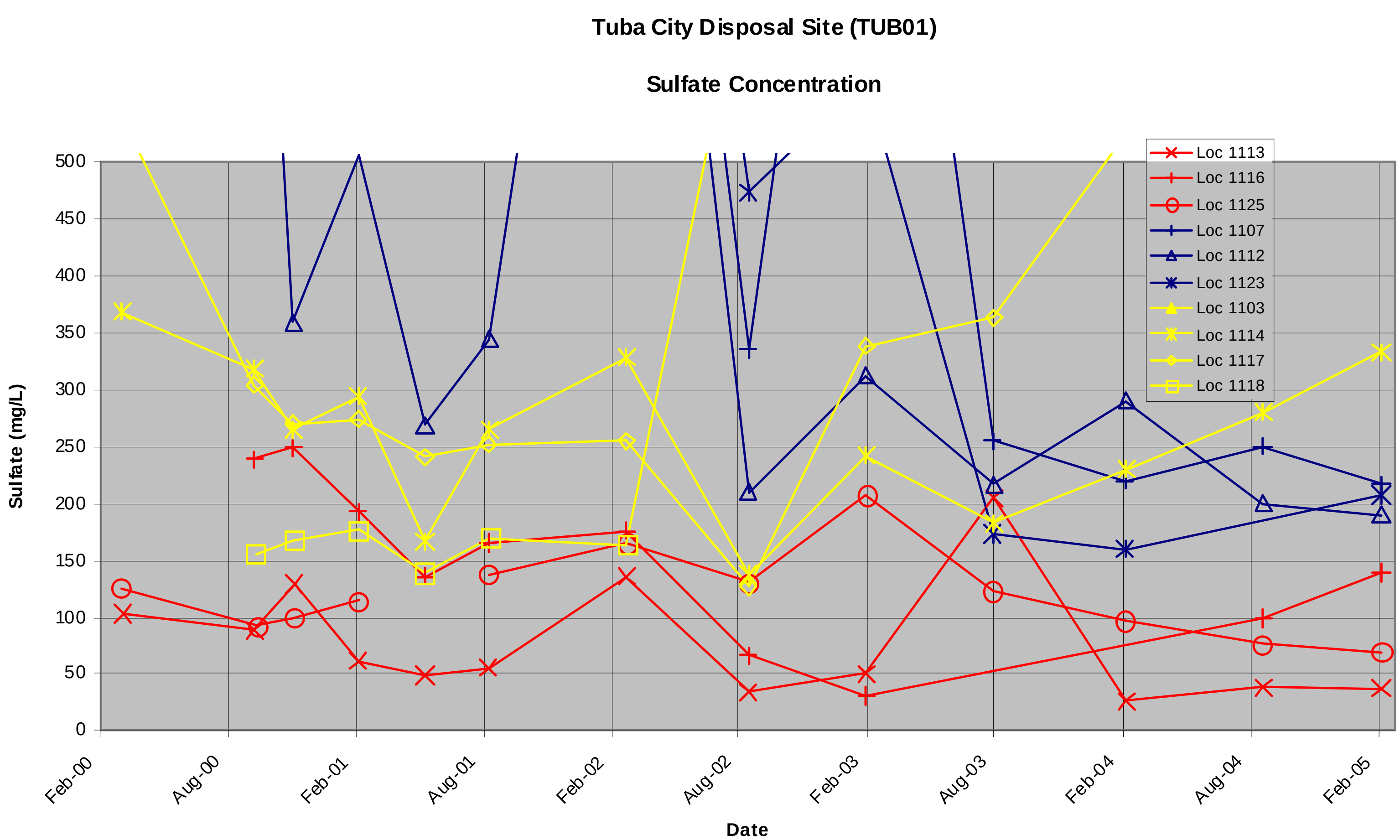

Figure 26. Sulfate Concentrations Trends Near Remediation Standard (250 mg/L) at Extraction Wells

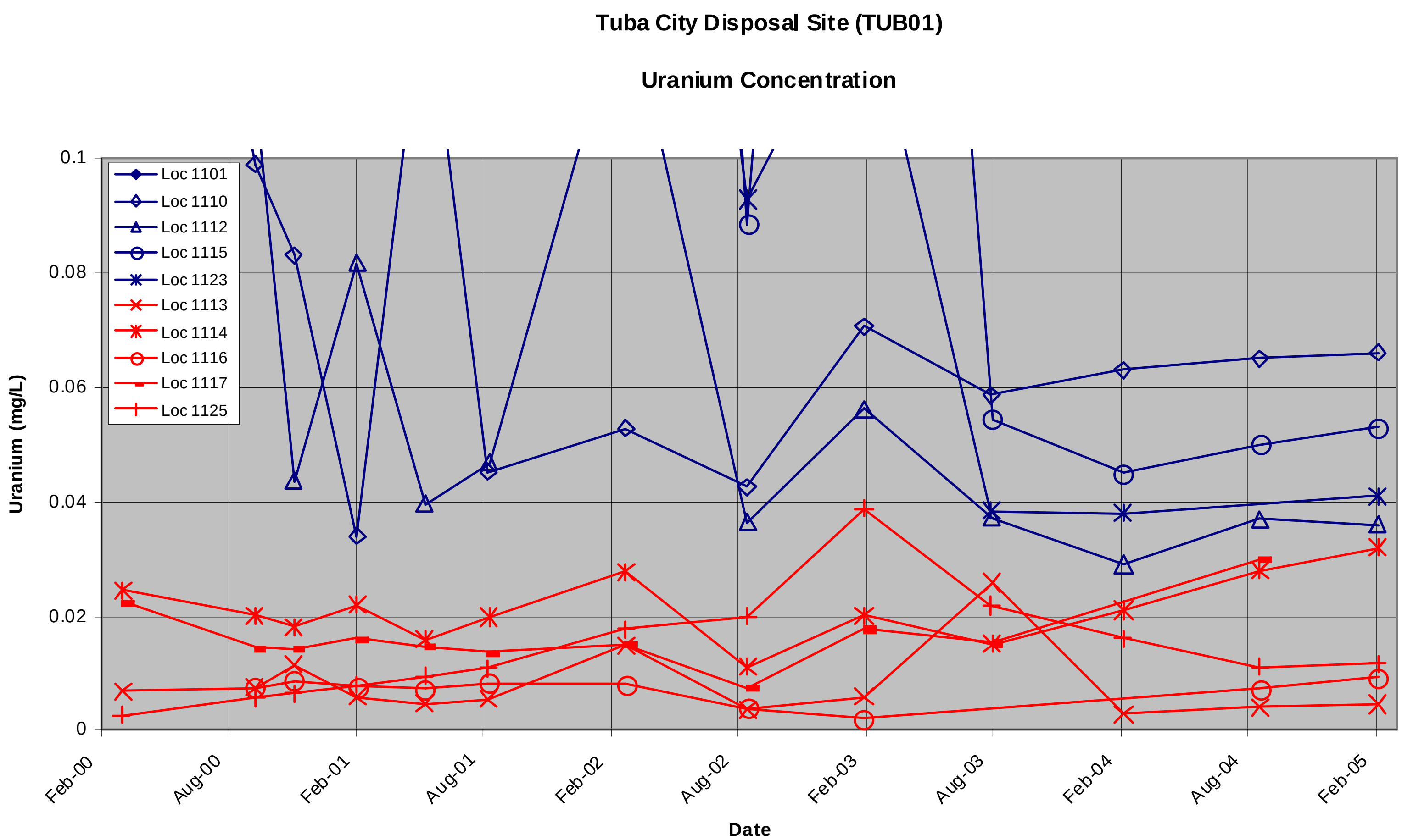

Figure 27. Uranium Concentrations Trends Near Remediation Standard (0.044 mg/L) at Extraction Wells

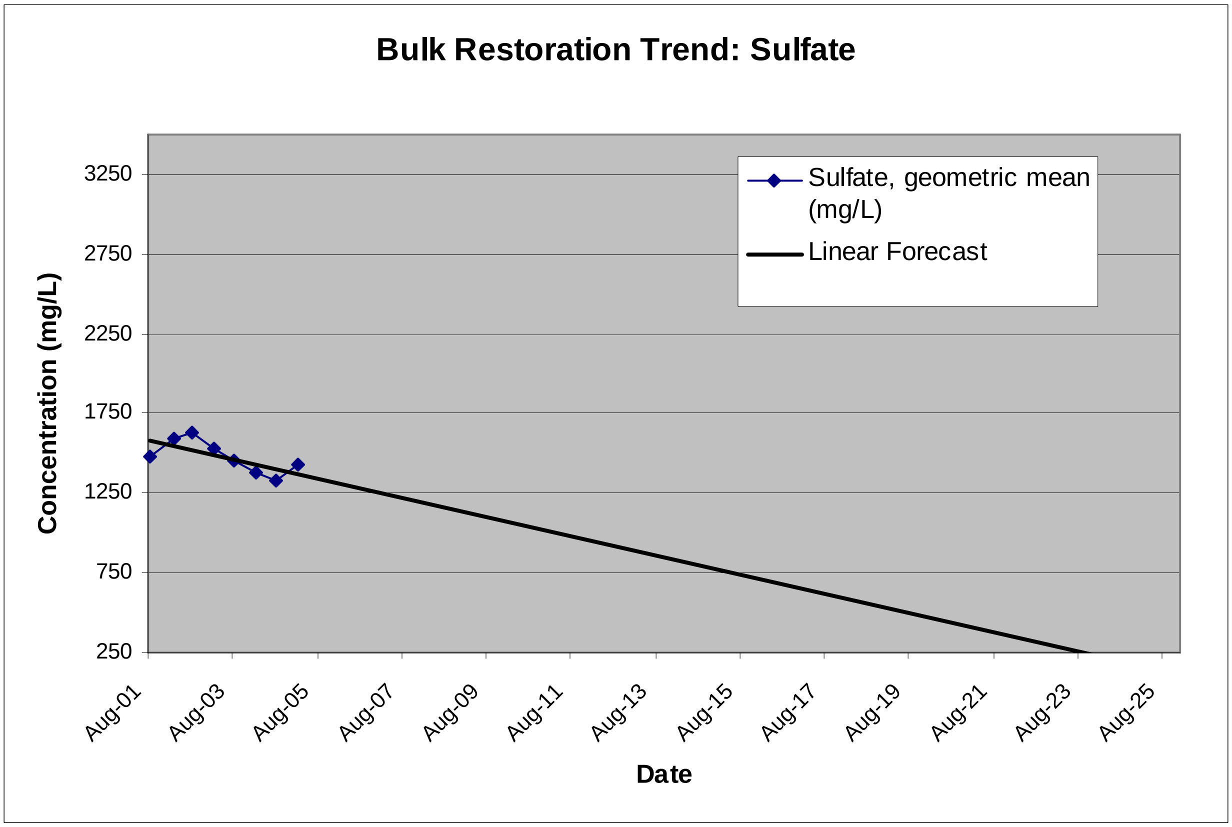

Figure 28. Bulk Restoration Trend for Sulfate

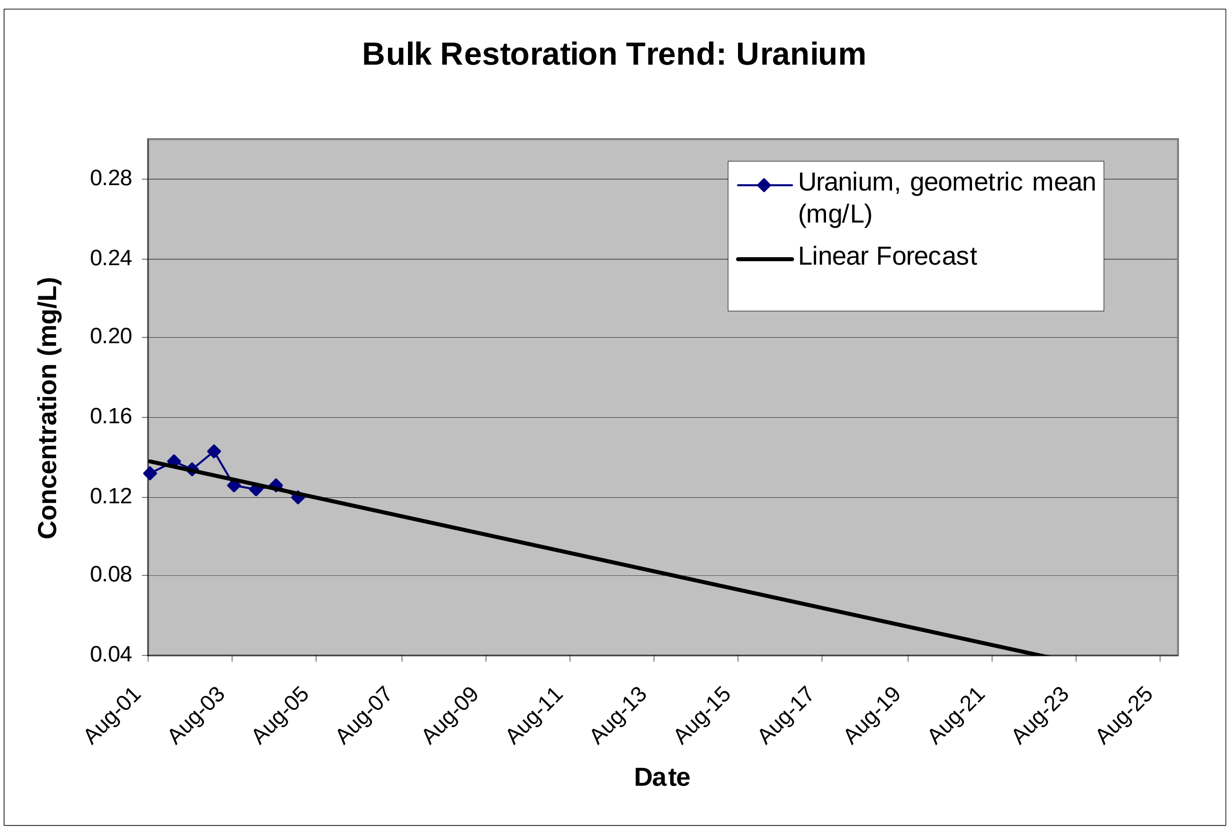

Figure 29. Bulk Restoration Trend for Uranium

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Appendix A

Tuba City Project Well Data

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Table A−1. Well Completion Information

WELL	TYPE	Horizon	TOP OF SCREEN ELEV	MID SCREEN ELEV	BOTTOM OF SCREEN ELEV	TOP OF SCREEN DEPTH	MID SCREEN DEPTH	BOTTOM OF SCREEN DEPTH	SCREEN LENGTH	SUMP LENGTH	WELL DEPTH
0284	MW	A	5079.8	5074.8	5069.8	16.5	21.5	26.5	10.0	1.5	28.0
0285	MW	A	5090.8	5088.3	5085.8	3.0	5.5	8.0	5.0	0.1	8.1
0686	MW	A	5045.5	5025.5	5005.5	60.0	80.0	100.0	40.0	0.3	100.3
0687	MW	A	5047.6	5027.6	5007.6	60.0	80.0	100.0	40.0	0.3	100.3
0688	MW	A	5044.1	5024.1	5004.1	60.0	80.0	100.0	40.0	0.3	100.3
0901	MW	A	5045.8	5035.8	5025.8	58.0	68.0	78.0	20.0	2.0	80.0
0906	MW	A	5016.9	5006.9	4996.9	44.0	54.0	64.0	20.0	2.0	66.0
0907	MW	A	5010.7	5000.7	4990.7	66.5	76.5	86.5	20.0		
0928	MW	A	5022.1	5009.6	4997.1	30.0	42.5	55.0	25.0	3.0	58.0
0929	MW	A	5010.4	4990.4	4970.4	48.2	68.2	88.2	40.0		
0940	MW	A	5017.9	5010.4	5002.9	45.0	52.5	60.0	15.0	3.0	68.0
0941	MW	A	5018.0	5008.0	4998.0	45.0	55.0	65.0	20.0	3.0	68.0
0945	MW	A	5028.1	5018.1	5008.1	110.0	120.0	130.0	20.0	3.0	133.0
0946	MW	A	5057.6	5047.6	5037.6	40.0	50.0	60.0	20.0	3.3	63.3
0262	MW	B	4999.2	4979.2	4959.2	60.0	80.0	100.0	40.0	0.3	100.3
0263	MW	B	5000.2	4980.2	4960.2	60.0	80.0	100.0	40.0	0.3	100.3
0265	MW	B	4991.1	4971.1	4951.1	60.0	80.0	100.0	40.0	0.3	100.3
0267	MW	B	4990.8	4970.8	4950.8	60.0	80.0	100.0	40.0	0.3	100.3
0271	MW	B	4984.0	4964.0	4944.0	60.0	80.0	100.0	40.0	0.3	100.3
0281	MW	B	4977.8	4972.8	4967.8	70.5	75.5	80.5	10.0	1.5	82.0
0282	MW	B	4983.3	4978.3	4973.3	74.1	79.1	84.1	10.0	1.5	85.6
0283	MW	B	4984.8	4979.8	4974.8	70.5	75.5	80.5	10.0	1.5	82.0
0905	MW	B	5006.0	4998.5	4991.0	63.0	70.5	78.0	15.0	2.0	80.0
0908	MW	B	5005.3	4997.8	4990.3	52.0	59.5	67.0	15.0	2.0	69.0
0909	MW	B	4990.8	4983.3	4975.8	65.0	72.5	80.0	15.0	2.0	82.0
0910	MW	B	5007.6	4957.6	4907.6	97.0	147.0	197.0	100.0	1.0	198.0
0918	MW	B	4986.2	4983.7	4981.2	61.0	63.5	66.0	5.0	2.0	68.0
0925	EXT	B	5005.8	4985.8	4965.8	53.0	73.0	93.0	40.0	0.5	93.5
0926	EXT	B	5018.3	4993.3	4968.3	42.2	67.2	92.2	50.0	3.0	95.2
0933	MW	B	4993.3	4992.3	4991.3	23.0	24.0	25.0	2.0		
0934	MW	B	5013.0	4990.5	4968.0	45.0	67.5	90.0	45.0	3.0	93.0
0935	MW	B	5008.8	4988.8	4968.8	50.0	70.0	90.0	40.0	3.0	93.0
0936	MW	B	5017.9	4997.9	4977.9	42.0	62.0	82.0	40.0	3.0	85.0
0937	MW	B	5020.2	4992.7	4965.2	40.0	67.5	95.0	55.0	3.0	98.0
0938	MW	B	5020.4	4992.9	4965.4	40.0	67.5	95.0	55.0	3.0	98.0
0939	EXT	B	5021.1	4993.6	4966.1	40.0	67.5	95.0	55.0	3.0	98.0
0942	MW	B	5009.5	4999.5	4989.5	54.0	64.0	74.0	20.0	3.0	77.0
0943	MW	B	4994.1	4984.1	4974.1	101.0	111.0	121.0	20.0	3.0	124.0
0944	MW	B	4979.9	4969.9	4959.9	85.0	95.0	105.0	20.0	2.0	107.0
0947	MW	B	4990.0	4980.0	4970.0	105.0	115.0	125.0	20.0	3.3	128.3
1126	EXT	B	4991.9	4971.9	4951.9	60.0	80.0	100.0	40.0	3.3	103.3
1127	EXT	B	4984.2	4964.2	4944.2	72.7	92.7	112.7	40.0	3.3	116.0
1128	EXT	B	4982.3	4962.3	4942.3	72.7	92.7	112.7	40.0	3.3	116.0
1129	EXT	B	4990.9	4975.9	4960.9	68.2	83.2	98.2	30.0	3.3	101.5
1130	EXT	B	4987.3	4962.3	4937.3	71.7	96.7	121.7	50.0	3.3	125.0
1131	EXT	B	4998.1	4978.1	4958.1	59.7	79.7	99.7	40.0	3.3	103.0
1132	EXT	B	5009.1	4984.1	4959.1	49.7	74.7	99.7	50.0	3.3	103.0
1133	EXT	B	4999.4	4979.4	4959.4	59.7	79.7	99.7	40.0	3.3	103.0
0274	MW	C	4913.6	4903.6	4893.6	149.0	159.0	169.0	20.0	1.5	170.5
0276	MW	C	4910.0	4900.0	4890.0	154.5	164.5	174.5	20.0	1.5	176.0
0279	MW	C	4922.1	4917.1	4912.1	26.5	31.5	36.5	10.0	1.5	38.0
0280	MW	C	4922.6	4917.6	4912.6	26.5	31.5	36.5	10.0	1.5	38.0
0683	MW	C	4973.2	4948.2	4923.2	95.0	120.0	145.0	50.0	3.0	148.0
0684	MW	C	4943.1	4917.4	4891.8	124.2	149.9	175.5	51.3	2.5	178.0
0685	MW	C	4975.6	4949.7	4923.8	93.7	119.6	145.5	51.8	2.5	148.0
0689	MW	C	4923.9	4903.9	4883.9	55.0	75.0	95.0	40.0	0.3	95.3
0691	MW	C	4921.9	4901.9	4881.9	55.0	75.0	95.0	40.0	0.3	95.3
0903	MW	C	4953.5	4943.5	4933.5	28.0	38.0	48.0	20.0	2.0	50.0
0912	MW	C	4934.7	4914.7	4894.7	123.0	143.0	163.0	40.0	2.0	165.0
0914	MW	C	4930.3	4921.8	4913.3	137.2	145.7	154.2	17.0	2.0	156.2
0917	MW	C	4917.8	4907.8	4897.8	128.0	138.0	148.0	20.0	2.0	150.0
0930	MW	C	4933.0	4918.0	4903.0	20.0	35.0	50.0	30.0	3.0	53.0
0932	MW	C	4942.3	4932.3	4922.3	112.5	122.5	132.5	20.0	2.7	135.2
1008	INJ	C	4926.8	4901.6	4876.4	55.6	80.8	106.0	50.4	2.5	108.5
1116	EXT	C	4964.1	4912.5	4861.0	92.4	143.9	195.5	103.1	2.5	198.0
1117	EXT	C	4965.3	4913.7	4862.1	92.3	143.9	195.5	103.2	2.5	198.0
1118	EXT	C	4967.9	4915.1	4862.3	89.9	142.7	195.5	105.6	2.5	198.0
0258	MW	D	4894.0	4874.0	4854.0	159.0	179.0	199.0	40.0	0.3	199.3

Table A−1 (continued). Well Completion Information

WELL	TYPE	Horizon	TOP OF CASING ELEV		GROUND ELEV		WELL DIAMETER	BORING STARTED	DECOMMISSION DATE	STATE PLANE EAST	STATE PLANE NORTH
0284	MW	A	5098.72		5096.3		2	16-Aug-04		730525	1873562
0285	MW	A	5096.47		5093.8		2	16-Aug-04		731629	1874042
0686	MW	A	5107.97		5105.5		2	28-Mar-00		729978	1873416
0687	MW	A	5109.82		5107.6		2	29-Mar-00		731152	1874024
0688	MW	A	5106.98		5104.1		2	29-Mar-00		731961	1874385
0901	MW	A	5105.46		5103.8		2	16-Oct-84		730185	1875918
0906	MW	A	5062.10		5060.9		2	19-Nov-84		730838	1872181
0907	MW	A	5079.17		5077.2		2	30-Nov-84	19-Apr-88	731252	1872920
0928	MW	A	5053.99		5052.1		4	20-Oct-95	24-May-00	729401	1870814
0929	MW	A	5060.82		5058.6		4			728780	1871453
0940	MW	A	5064.77		5062.9		4	01-Nov-95		730130	1872391
0941	MW	A	5065.97		5063.0		4	10-Nov-95		730908	1872398
0945	MW	A	5140.49		5138.1		4	11-Oct-95		730019	1873857
0946	MW	A	5100.50		5097.6		4	02-Nov-95		730547	1873582
0262	MW	B	5061.99		5059.2		2	03-Apr-00		731402	1872012
0263	MW	B	5063.10		5060.2		2	04-Apr-00		731565	1871757
0265	MW	B	5053.88		5051.1		2	16-Apr-00		730382	1870964
0267	MW	B	5053.40		5050.8		2	14-Apr-00		729329	1870707
0271	MW	B	5046.72		5044.0		2	29-Apr-00		728160	1869555
0281	MW	B	5051.00		5048.3		2	11-Aug-04		729714	1870315
0282	MW	B	5060.04		5057.4		2	10-Aug-04		730062	1871168
0283	MW	B	5057.97		5055.3		2	03-Aug-04		730901	1871185
0905	MW	B	5072.80		5069.0		2	14-Nov-84	24-May-00	732933	1873200
0908	MW	B	5058.14		5057.3		2	17-Nov-84		729366	1871999
0909	MW	B	5057.17		5055.8		2	18-Nov-84		730927	1871393
0910	MW	B	5106.70		5104.6		4	26-Jul-85		730219	1875840
0918	MW	B	5049.63		5047.2		4	15-Aug-85		727294	1868724
0925	EXT	B	5060.87		5058.8		6	21-Oct-95	24-May-00	729452	1872006
0926	EXT	B	5062.85		5060.5		6	25-Oct-95	17-May-00	730790	1872126
0933	MW	B	5018.03		5016.3		4	18-Oct-95	24-May-00	731727	1871341
0934	MW	B	5059.73		5058.0		4	02-Nov-95		730018	1871649
0935	MW	B	5061.50		5058.8		4	28-Oct-95 *		729461	1871978
0936	MW	B	5062.30		5059.9		6	26-Oct-95 *		730055	1872121
0937	MW	B	5062.80		5060.2		4	09-Nov-95	24-May-00	730790	1872116
0938	MW	B	5063.64		5060.4		4	26-Oct-95 *		730769	1872124
0939	EXT	B	5063.23		5061.1		6	23-Oct-95	16-May-00	731403	1872132
0942	MW	B	5066.45		5063.5		4	03-Nov-95 *		731642	1872409
0943	MW	B	5098.05		5095.1		4	13-Oct-95		731596	1874034
0944	MW	B	5067.00		5064.9		4	04-Nov-95	28-Jul-99	732199	1873007
0947	MW	B	5097.01		5095.0		4	03-Nov-95		732786	1874642
1126	EXT	B	*5051.9*	**	*5051.9*	**	4	09-Sep-04		729517	1870728
1127	EXT	B	*5056.9*	**	*5056.9*	**	4	11-Sep-04		730044	1871022
1128	EXT	B	*5055.0*	**	*5055.0*	**	4	12-Sep-04		730679	1871294
1129	EXT	B	*5059.1*	**	*5059.1*	**	4	30-Aug-04		731237	1871690
1130	EXT	B	*5059.0*	**	*5059.0*	**	4	29-Jul-04		731699	1871907
1131	EXT	B	*5057.8*	**	*5057.8*	**	4	08-Sep-04		732011	1872106
1132	EXT	B	*5058.8*	**	*5058.8*	**	4	31-Aug-04		731310	1872015
1133	EXT	B	*5059.1*	**	*5059.1*	**	4	02-Sep-04		730850	1871827
0274	MW	C	5064.42		5062.6		2	30-Aug-04		731623	1872403
0276	MW	C	5067.55		5064.5		2	01-Sep-04		732081	1873158
0279	MW	C	4951.04		4948.6		2	15-Aug-04		731494	1870132
0280	MW	C	4951.52		4949.1		2	15-Aug-04		731794	1870289
0683	MW	C	5070.64		5068.2		6	31-Aug-99		732661	1872574
0684	MW	C	5070.05		5067.3		6	20-Aug-99		732642	1873521
0685	MW	C	5072.44		5069.3		6	19-Aug-99		732295	1873760
0689	MW	C	4981.63		4978.9		2	31-Mar-00		730439	1869893
0691	MW	C	4979.41		4976.9		2	30-Mar-00		732124	1870872
0903	MW	C	4983.33		4981.5		2	30-Oct-84		731314	1870829
0912	MW	C	5059.97		5057.7		4	12-Aug-85		729324	1871942
0914	MW	C	5070.10		5067.5		4	16-Aug-85		732723	1872119
0917	MW	C	5048.02		5045.8		4	14-Aug-85		727255	1868642
0930	MW	C	4954.96		4953.0		4	23-Oct-95		731257	1870099
0932	MW	C	5057.32		5054.8		4	29-Oct-95		730900	1871401
1008	INJ	C	4980.52		4982.3		6	23-Jul-99		730410	1869916
1116	EXT	C	5053.74		5056.5		6	08-Aug-99		730350	1871702
1117	EXT	C	5054.95		5057.6		6	11-Aug-99		729981	1871688
1118	EXT	C	5055.11		5057.8		6	12-Aug-99		729756	1871695
0258	MW	D	5055.56		5053.0		2	13-Apr-00		732452	1871996

Table A−1 (continued). Well Completion Information

WELL	TYPE	Horizon	TOP OF SCREEN ELEV	MID SCREEN ELEV	BOTTOM OF SCREEN ELEV	TOP OF SCREEN DEPTH	MID SCREEN DEPTH	BOTTOM OF SCREEN DEPTH	SCREEN LENGTH	SUMP LENGTH	WELL DEPTH
0692	MW	D	4895.6	4875.6	4855.6	55.0	75.0	95.0	40.0	0.3	95.3
0695	MW	D	4919.3	4899.3	4879.3	55.0	75.0	95.0	40.0	0.3	95.3
0904	MW	D	4873.8	4868.8	4863.8	28.0	33.0	38.0	10.0	2.0	40.0
0915	MW	D	4897.8	4892.8	4887.8	170.0	175.0	180.0	10.0	2.0	182.0
1003	INJ	D	4923.4	4898.4	4873.4	55.5	80.5	105.5	50.0	2.5	108.0
1004	INJ	D	4918.1	4893.1	4868.1	45.5	70.5	95.5	50.0	2.5	98.0
1005	INJ	D	4904.7	4879.7	4854.7	45.5	70.5	95.5	50.0	2.5	98.0
1006	INJ	D	4903.7	4878.7	4853.7	45.7	70.7	95.7	50.0	2.5	98.2
1007	INJ	D	4915.6	4890.5	4865.4	45.8	70.9	96.0	50.2	2.5	98.5
1101	EXT	D	4974.2	4896.5	4818.9	96.1	173.8	251.5	155.4	2.5	254.0
1102	EXT	D	4968.8	4893.8	4818.8	101.5	176.5	251.5	150.0	2.5	254.0
1103	EXT	D	4962.3	4887.3	4812.3	100.0	175.0	250.0	150.0	2.5	252.5
1104	EXT	D	4972.3	4894.8	4817.3	90.0	167.5	245.0	155.0	3.0	248.0
1105	EXT	D	4972.1	4894.6	4817.1	90.0	167.5	245.0	155.0	3.0	248.0
1106	EXT	D	4966.0	4888.7	4811.4	96.5	173.8	251.1	154.6	2.9	254.0
1107	EXT	D	4971.2	4894.0	4816.8	91.1	168.3	245.5	154.4	2.5	248.0
1108	EXT	D	4966.1	4891.1	4816.1	96.3	171.3	246.3	150.0	2.5	248.8
1109	EXT	D	4972.1	4894.7	4817.3	90.3	167.7	245.1	154.8	2.9	248.0
1110	EXT	D	4966.8	4891.8	4816.8	95.5	170.5	245.5	150.0	2.5	248.0
1111	EXT	D	4971.9	4894.7	4817.5	90.7	167.9	245.1	154.4	2.5	247.6
1112	EXT	D	4969.1	4891.6	4814.1	90.5	168.0	245.5	155.0	2.5	248.0
1113	EXT	D	4968.7	4891.2	4813.7	90.5	168.0	245.5	155.0	2.5	248.0
1114	EXT	D	4968.5	4891.0	4813.6	90.6	168.0	245.5	154.9	2.5	248.0
1115	EXT	D	4968.6	4891.2	4813.7	90.5	168.0	245.5	155.0	2.5	248.0
1119	EXT	D	4968.7	4893.7	4818.7	95.3	170.3	245.3	150.0	2.5	247.8
1120	EXT	D	4971.0	4896.0	4821.0	95.5	170.5	245.5	150.0	2.5	248.0
1121	EXT	D	4972.0	4897.0	4822.0	97.5	172.5	247.5	150.0	2.5	250.0
1122	EXT	D	4973.4	4896.3	4819.2	96.9	174.0	251.1	154.2	2.9	254.0
1123	EXT	D	4976.2	4899.2	4822.2	91.0	168.0	245.0	154.0	3.0	248.0
1124	EXT	D	4978.7	4899.9	4821.1	87.9	166.7	245.5	157.6	2.5	248.0
1125	EXT	D	4972.8	4897.8	4822.8	95.5	170.5	245.5	150.0	2.5	248.0
0251	MW	E	4858.9	4808.9	4758.9	200.0	250.0	300.0	100.0	0.3	300.3
0268	MW	E	4864.5	4814.5	4764.5	200.0	250.0	300.0	100.0	0.3	300.3
0920	MW	E	4866.0	4846.0	4826.0	114.4	134.4	154.4	40.0	2.0	156.4
0948	EXDS	E	4893.9	4803.9	4713.9	221.5	311.5	401.5	180.0	5.0	406.5
0911	MW	F	4795.2	4775.2	4755.2	309.4	329.4	349.4	40.0	2.0	351.4
0913	MW	G	4729.2	4709.2	4689.2	328.7	348.7	368.7	40.0	2.0	370.7
0916	MW	G	4721.7	4716.7	4711.7	345.7	350.7	355.7	10.0	2.0	357.7
0919	MW	G	4707.9	4702.9	4697.9	337.7	342.7	347.7	10.0	2.0	349.7
0902	MW	H	4673.7	4668.7	4663.7	63.0	68.0	73.0	10.0	2.0	75.0
0252	MW	I	4658.9	4608.9	4558.9	400.0	450.0	500.0	100.0	0.4	500.4
0254	MW	I	4662.7	4612.7	4562.7	400.0	450.0	500.0	100.0	0.4	500.4
0256	MW	I	4664.0	4614.0	4564.0	400.0	450.0	500.0	100.0	0.4	500.4
0921	MW	I	4663.7	4643.7	4623.7	313.2	333.2	353.2	40.0	2.0	355.2
0253	MW	M	4458.8	4408.8	4358.8	600.0	650.0	700.0	100.0	0.4	700.4
0255	MW	M	4462.3	4412.3	4362.3	600.0	650.0	700.0	100.0	0.4	700.4
0257	MW	M	4463.4	4413.4	4363.4	600.0	650.0	700.0	100.0	0.4	700.4
0968	EXDS		5000.4	4699.9	4399.4	106.0	406.5	707.0	601.0	0.0	707.0
0970	EXDS		5007.7	4705.2	4402.7	100.0	402.5	705.0	605.0	0.0	705.0
0971	EXDS		4985.3	4693.8	4402.3	117.0	408.5	700.0	583.0	0.0	700.0
0972	EXDS		5039.7	4724.7	4409.7	100.0	415.0	730.0	630.0	0.0	730.0

Table A−1 (continued). Well Completion Information

WELL	TYPE	Horizon	TOP OF CASING ELEV	GROUND ELEV	WELL DIAMETER	BORING STARTED	DECOMMISSION DATE	STATE PLANE EAST	STATE PLANE NORTH
0692	MW	D	4953.31	4950.6	2	05-Apr-00		731821	1870303
0695	MW	D	4976.83	4974.3	2	06-Apr-00		732566	1870896
0904	MW	D	4904.11	4901.8	2	07-Nov-84		731808	1868036
0915	MW	D	5070.84	5067.8	4	24-Aug-85		732740	1872209
1003	INJ	D	4976.58	4978.9	6	26-Jul-99		732101	1870898
1004	INJ	D	4961.55	4963.6	6	27-Jul-99		731892	1870544
1005	INJ	D	4947.83	4950.2	6	25-Jul-99		731496	1870168
1006	INJ	D	4947.08	4949.5	6	24-Jul-99		731233	1869918
1007	INJ	D	4958.56	4961.4	6	23-Jul-99		730770	1869861
1101	EXT	D	5067.29	5070.4	6	24-Aug-99		732223	1872970
1102	EXT	D	5066.76	5070.3	6	24-Aug-99		732225	1872670
1103	EXT	D	5059.56	5062.3	6	30-Jul-99		731896	1872407
1104	EXT	D	5059.57	5062.3	6	01-Aug-99		731527	1872404
1105	EXT	D	5059.33	5062.1	6	02-Aug-99		731304	1872401
1106	EXT	D	5059.73	5062.5	6	03-Aug-99		731081	1872400
1107	EXT	D	5059.51	5062.3	6	03-Aug-99		730858	1872398
1108	EXT	D	5059.62	5062.4	6	03-Aug-99		730634	1872396
1109	EXT	D	5059.64	5062.4	6	04-Aug-99		730410	1872394
1110	EXT	D	5059.47	5062.3	6	07-Aug-99		730187	1872392
1111	EXT	D	5059.87	5062.6	6	06-Aug-99		729993	1872392
1112	EXT	D	5057.08	5059.6	6	17-Aug-99		730494	1872064
1113	EXT	D	5058.54	5059.2	6	17-Aug-99		730196	1872061
1114	EXT	D	5056.25	5059.1	6	11-Aug-99		729896	1872057
1115	EXT	D	5056.36	5059.2	6	07-Aug-99		729596	1872055
1119	EXT	D	5061.19	5064.0	6	31-Jul-99		731894	1872667
1120	EXT	D	5063.60	5066.5	6	28-Jul-99		731891	1872967
1121	EXT	D	5066.61	5069.5	6	28-Jul-99		731889	1873267
1122	EXT	D	5067.31	5070.3	6	26-Aug-99		732221	1873269
1123	EXT	D	5064.54	5067.2	6	02-Sep-99		732508	1873222
1124	EXT	D	5063.86	5066.6	6	23-Aug-99		732512	1872972
1125	EXT	D	5065.47	5068.3	6	25-Aug-99		732515	1872671
0251	MW	E	5061.25	5058.9	2	28-Apr-00		730215	1871999
0268	MW	E	5067.24	5064.5	2	15-May-00		732301	1872430
0920	MW	E	4982.97	4980.4	4	30-Jul-85		731262	1870737
0948	EXDS	E	5117.80	5115.4	4	17-Oct-95		733915	1875516
0911	MW	F	5106.96	5104.6	4	18-Jul-85		730265	1875920
0913	MW	G	5060.16	5057.9	4	02-Aug-85		729327	1871871
0916	MW	G	5070.00	5067.4	4	22-Aug-85		732811	1872146
0919	MW	G	5048.56	5045.6	4	26-Aug-85		727353	1868654
0902	MW	H	4737.42	4736.7	2	02-Dec-84		730179	1862292
0252	MW	I	5061.30	5058.9	4	26-Apr-00		730232	1871993
0254	MW	I	5065.38	5062.7	4	03-May-00		730951	1872411
0256	MW	I	5066.58	5064.0	4	13-May-00		732277	1872437
0921	MW	I	4979.08	4976.9	4	22-Jul-85		731379	1870742
0253	MW	M	5061.11	5058.8	4	18-Apr-00	11-Apr-01	730213	1871974
0255	MW	M	5064.89	5062.3	4	01-May-00		730947	1872387
0257	MW	M	5066.40	5063.4	4	11-May-00		732278	1872414
0968	EXDS		5107.00	5106.4	10			730180	1875689
0970	EXDS		5109.53	5107.7	10			730653	1876567
0971	EXDS		5104.00	5102.3	10			731590	1878306
0972	EXDS		5141.07	5139.7	10			728031	1877986

ALL DIMENSIONS IN FEET EXCEPT WELL DIAMETER IN INCHES
ALL DEPTHS ARE RELATIVE TO GROUND SURFACE

MW	MONITOR WELL
EXT	GROUNDWATER REMEDIATION EXTRACTION WELL
INJ	GROUNDWATER REMEDIATION INJECTION WELL
EXDS	OTHER SUPPLY WELL
**	APPROXIMATE

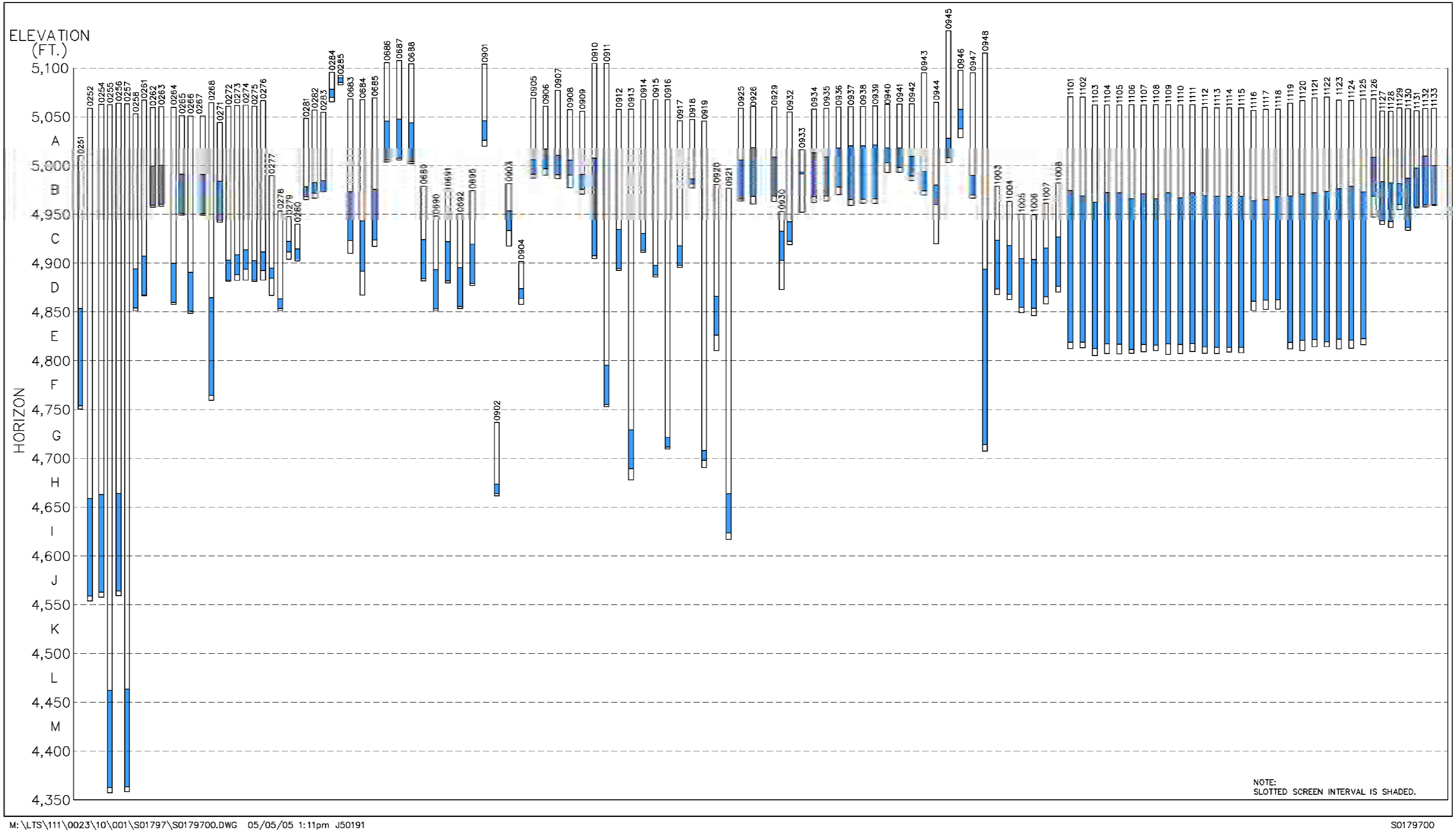

Figure A–1. Well Completions Schematic

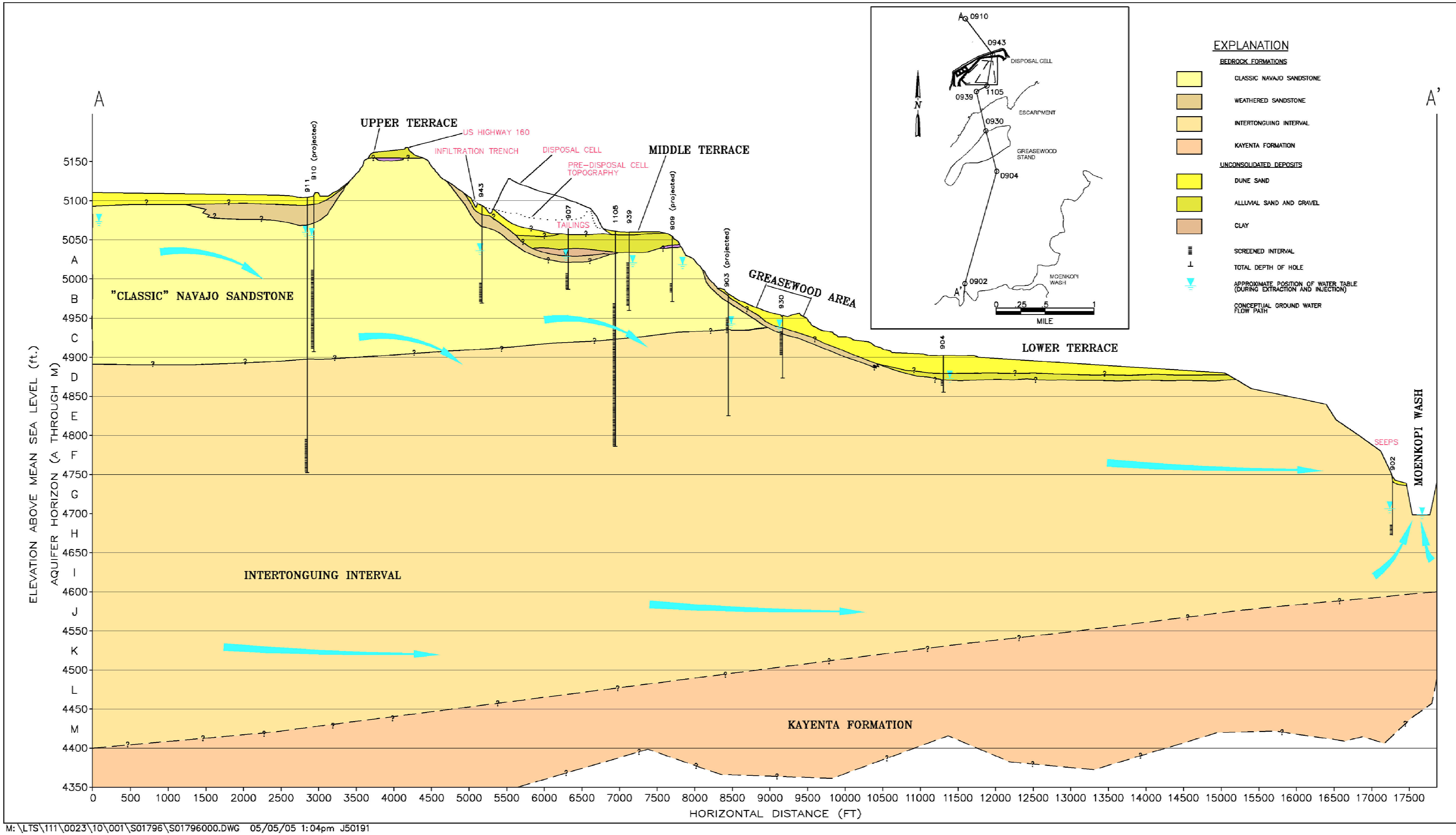

Figure A−2. Conceptual Model of the Site Hydrogeology

Table A−2. Extraction Well Operation Summary—March 2004 through March 2005

TUBA CITY EXTRACTION WELL OPERATIONAL SUMMARY: MARCH 2004 THROUGH MARCH 2005												
	Mar-04						Apr-04					
	Total Time On	28.82	days	q1	q2	q3	Total Time On	29.97	days	q1	q2	q3
Well	Total Time	Pump OST	Gallons	gpm	gpm	gpm	Total Time	OST	Gallons	gpm	gpm	gpm
1101	26.39	92%	201,345	5.3	4.9	4.5	29.97	100%	246,613	5.7	5.7	5.7
1102	27.19	94%	218,507	5.6	5.3	4.9	29.96	100%	235,135	5.4	5.4	5.4
1103	27.30	95%	252,458	6.4	6.1	5.7	29.95	100%	277,906	6.4	6.4	6.4
1104	27.18	94%	167,683	4.3	4.0	3.8	29.97	100%	172,911	4.0	4.0	4.0
1105	14.46	50%	214,388	10.3	5.2	4.8	14.94	50%	221,997	10.3	5.1	5.1
1106	18.95	66%	112,722	4.1	2.7	2.5	17.44	58%	75,777	3.0	1.8	1.8
1107	25.91	90%	148,146	4.0	3.6	3.3	29.97	100%	158,977	3.7	3.7	3.7
1108	27.30	95%	185,771	4.7	4.5	4.2	29.97	100%	201,853	4.7	4.7	4.7
1109	27.30	95%	95,480	2.4	2.3	2.1	29.97	100%	98,234	2.3	2.3	2.3
1110	24.84	86%	141,352	4.0	3.4	3.2	26.10	87%	139,673	3.7	3.2	3.2
1111	27.30	95%	156,559	4.0	3.8	3.5	29.97	100%	166,638	3.9	3.9	3.9
1112	13.92	48%	83,335	4.2	2.0	1.9	13.48	45%	82,197	4.2	1.9	1.9
1113	18.37	64%	101,407	3.8	2.4	2.3	18.72	62%	99,809	3.7	2.3	2.3
1114	26.73	93%	201,388	5.2	4.9	4.5	29.85	100%	214,936	5.0	5.0	5.0
1115	27.30	95%	245,728	6.2	5.9	5.5	29.97	100%	267,764	6.2	6.2	6.2
1116	0.00	0%	0	0.0	0.0	0.0	0.00	0%	0	0.0	0.0	0.0
1117	0.00	0%	0	0.0	0.0	0.0	0.00	0%	0	0.0	0.0	0.0
1118	26.93	93%	54,936	1.4	1.3	1.2	3.29	11%	8,051	1.7	0.2	0.2
1119	27.30	95%	127,575	3.2	3.1	2.9	29.97	100%	137,831	3.2	3.2	3.2
1120	9.51	33%	31,002	2.3	0.7	0.7	8.28	28%	18,110	1.5	0.4	0.4
1121	26.24	91%	177,929	4.7	4.3	4.0	29.95	100%	197,947	4.6	4.6	4.6
1122	27.30	95%	130,969	3.3	3.2	2.9	29.97	100%	132,933	3.1	3.1	3.1
1123	12.91	45%	16,015	0.9	0.4	0.4	12.78	43%	15,346	0.8	0.4	0.4
1124	27.17	94%	165,957	4.2	4.0	3.7	29.97	100%	172,956	4.0	4.0	4.0
1125	27.17	94%	149,425	3.8	3.6	3.3	29.96	100%	158,429	3.7	3.7	3.7
		total gallons	3,380,078						3,502,022			
		operating q gpm	81.5						81.1			
		days/month	31						30			
		avg monthly q gpm	76						81			
			avg well q gpm	3.9	3.3	3.0				3.8	3.2	3.2
	May-04						Jun-04					
	Total Time On	29.65	days	q1	q2	q3	Total Time On	27.62	days	q1	q2	q3
Well	Total Time	OST	Gallons	gpm	gpm	gpm	Total Time	OST	Gallons	gpm	gpm	gpm
1101	29.65	100%	239,097	5.6	5.6	5.4	25.90	94%	212,103	5.7	5.3	4.9
1102	29.64	100%	221,770	5.2	5.2	5.0	27.58	100%	199,460	5.0	4.6	4.6
1103	29.64	100%	273,580	6.4	6.4	6.1	27.56	100%	251,638	6.3	5.8	5.8
1104	29.64	100%	174,268	4.1	4.1	3.9	27.61	100%	166,606	4.2	3.9	3.9
1105	15.58	53%	235,556	10.5	5.5	5.3	14.89	54%	228,802	10.7	5.3	5.3
1106	0.00	0%	0	0.0	0.0	0.0	4.92	18%	16,615	2.3	0.4	0.4
1107	29.64	100%	160,947	3.8	3.8	3.6	27.61	100%	150,662	3.8	3.5	3.5
1108	29.64	100%	198,165	4.6	4.6	4.4	27.58	100%	184,691	4.7	4.3	4.3
1109	29.64	100%	99,606	2.3	2.3	2.2	27.61	100%	97,037	2.4	2.2	2.2
1110	26.54	90%	142,082	3.7	3.3	3.2	26.93	98%	140,633	3.6	3.3	3.3
1111	29.64	100%	161,708	3.8	3.8	3.6	27.60	100%	149,226	3.8	3.5	3.5
1112	14.14	48%	85,179	4.2	2.0	1.9	13.63	49%	84,030	4.3	1.9	1.9
1113	19.12	64%	101,170	3.7	2.4	2.3	18.13	66%	98,327	3.8	2.3	2.3
1114	29.52	100%	214,036	5.0	5.0	4.8	26.86	97%	201,292	5.2	4.7	4.7
1115	29.64	100%	264,558	6.2	6.2	5.9	27.61	100%	245,317	6.2	5.7	5.7
1116	0.00	0%	0	0.0	0.0	0.0	0.00	0%	0	0.0	0.0	0.0
1117	0.00	0%	0	0.0	0.0	0.0	0.00	0%	0	0.0	0.0	0.0
1118	0.00	0%	0	0.0	0.0	0.0	0.00	0%	0	0.0	0.0	0.0
1119	29.64	100%	135,429	3.2	3.2	3.0	27.59	100%	125,245	3.2	2.9	2.9
1120	9.79	33%	54,994	3.9	1.3	1.2	11.73	42%	116,031	6.9	2.7	2.7
1121	29.64	100%	191,214	4.5	4.5	4.3	27.58	100%	180,293	4.5	4.2	4.2
1122	29.64	100%	129,453	3.0	3.0	2.9	27.60	100%	120,600	3.0	2.8	2.8
1123	12.35	42%	15,026	0.8	0.4	0.3	11.57	42%	14,296	0.9	0.3	0.3
1124	29.64	100%	168,198	3.9	3.9	3.8	27.61	100%	155,784	3.9	3.6	3.6
1125	29.63	100%	155,758	3.7	3.6	3.5	27.45	99%	143,650	3.6	3.3	3.3
		total gallons	3,421,796						3,282,335			
		operating q gpm	80.2						82.5			
		days/month	31						30			
		avg monthly q gpm	77						76			
			avg well q gpm	3.7	3.2	3.1				3.9	3.1	3.0
	Jul-04						Aug-04					
	Total Time On	18.13	days	q1	q2	q3	Total Time On	27.15	days	q1	q2	q3
Well	Total Time	OST	Gallons	gpm	gpm	gpm	Total Time	OST	Gallons	gpm	gpm	gpm
1101	18.11	100%	160,257	6.1	6.1	3.6	27.14	100%	237,360	6.1	6.1	5.3
1102	18.09	100%	133,501	5.1	5.1	3.0	27.12	100%	195,115	5.0	5.0	4.4

Table A−2 (continued). Extraction Well Operation Summary—March 2004 through March 2005

TUBA CITY EXTRACTION WELL OPERATIONAL SUMMARY: MARCH 2004 THROUGH MARCH 2005												
1103	18.07	100%	165,576	6.4	6.3	3.7	27.06	100%	247,916	6.4	6.3	5.6
1104	18.09	100%	121,855	4.7	4.7	2.7	27.07	100%	170,879	4.4	4.4	3.8
1105	16.59	92%	73,282	3.1	2.8	1.6	26.94	99%	116,902	3.0	3.0	2.6
1106	18.09	100%	73,453	2.8	2.8	1.6	27.14	100%	102,032	2.6	2.6	2.3
1107	18.09	100%	103,965	4.0	4.0	2.3	27.06	100%	146,982	3.8	3.8	3.3
1108	18.04	100%	121,815	4.7	4.7	2.7	27.00	99%	180,070	4.6	4.6	4.0
1109	17.93	99%	71,005	2.8	2.7	1.6	27.13	100%	98,705	2.5	2.5	2.2
1110	17.94	99%	104,731	4.1	4.0	2.3	27.09	100%	144,387	3.7	3.7	3.2
1111	17.98	99%	99,368	3.8	3.8	2.2	27.12	100%	144,622	3.7	3.7	3.2
1112	15.28	84%	64,267	2.9	2.5	1.4	23.63	87%	78,597	2.3	2.0	1.8
1113	7.34	41%	34,007	3.2	1.3	0.8	9.64	36%	38,251	2.8	1.0	0.9
1114	15.85	87%	120,264	5.3	4.6	2.7	24.39	90%	159,769	4.5	4.1	3.6
1115	17.93	99%	152,977	5.9	5.9	3.4	27.14	100%	223,578	5.7	5.7	5.0
1116	14.72	81%	88,472	4.2	3.4	2.0	27.14	100%	157,591	4.0	4.0	3.5
1117	14.73	81%	153,195	7.2	5.9	3.4	27.13	100%	281,086	7.2	7.2	6.3
1118	14.73	81%	74,320	3.5	2.8	1.7	19.80	73%	112,150	3.9	2.9	2.5
1119	18.00	99%	90,280	3.5	3.5	2.0	27.11	100%	127,825	3.3	3.3	2.9
1120	13.55	75%	156,382	8.0	6.0	3.5	19.12	70%	203,751	7.4	5.2	4.6
1121	18.00	99%	123,307	4.8	4.7	2.8	26.99	99%	183,732	4.7	4.7	4.1
1122	18.00	99%	87,014	3.4	3.3	1.9	27.14	100%	124,619	3.2	3.2	2.8
1123	4.14	23%	4,286	0.7	0.2	0.1	7.36	27%	6,491	0.6	0.2	0.1
1124	12.97	72%	81,951	4.4	3.1	1.8	0.00	0%	2	0.0	0.0	0.0
1125	17.86	99%	102,833	4.0	3.9	2.3	26.91	99%	156,487	4.0	4.0	3.5
		total gallons	2,562,362						3,638,897			
		operating q gpm	98.2						93.1			
		days/month	31						31			
		avg monthly q gpm	57						82			
			avg well q gpm	4.3	3.9	2.3				4.0	3.7	3.3
	Sep-04						Oct-04					
	Total Time On	13.46	days	q1	q2	q3	Total Time On	15.48	days	q1	q2	q3
Well	Total Time	OST	Gallons	gpm	gpm	gpm	Total Time	OST	Gallons	gpm	gpm	gpm
1101	13.42	100%	117,148	6.1	6.0	2.7	15.41	100%	138,626	6.2	6.2	3.1
1102	13.42	100%	98,372	5.1	5.1	2.3	15.42	100%	120,502	5.4	5.4	2.7
1103	13.39	100%	123,133	6.4	6.4	2.9	15.39	99%	142,499	6.4	6.4	3.2
1104	13.42	100%	90,508	4.7	4.7	2.1	15.40	99%	127,818	5.8	5.7	2.9
1105	13.42	100%	101,351	5.2	5.2	2.3	15.42	100%	116,318	5.2	5.2	2.6
1106	13.42	100%	49,919	2.6	2.6	1.2	15.42	100%	71,032	3.2	3.2	1.6
1107	13.42	100%	76,903	4.0	4.0	1.8	15.38	99%	96,473	4.4	4.3	2.2
1108	13.31	99%	90,199	4.7	4.7	2.1	14.88	96%	109,332	5.1	4.9	2.4
1109	13.42	100%	50,633	2.6	2.6	1.2	15.42	100%	69,710	3.1	3.1	1.6
1110	13.39	99%	79,678	4.1	4.1	1.8	15.41	100%	115,961	5.2	5.2	2.6
1111	13.42	100%	71,809	3.7	3.7	1.7	15.42	100%	89,586	4.0	4.0	2.0
1112	12.00	89%	47,464	2.7	2.4	1.1	15.40	100%	83,261	3.8	3.7	1.9
1113	6.55	49%	25,818	2.7	1.3	0.6	11.73	76%	45,543	2.7	2.0	1.0
1114	13.40	100%	92,869	4.8	4.8	2.1	15.38	99%	119,029	5.4	5.3	2.7
1115	13.42	100%	112,409	5.8	5.8	2.6	15.41	100%	137,116	6.2	6.1	3.1
1116	13.42	100%	76,866	4.0	4.0	1.8	15.41	100%	86,203	3.9	3.9	1.9
1117	13.42	100%	138,971	7.2	7.2	3.2	15.41	100%	159,966	7.2	7.2	3.6
1118	12.84	95%	74,759	4.0	3.9	1.7	15.42	100%	88,584	4.0	4.0	2.0
1119	13.42	100%	65,110	3.4	3.4	1.5	15.42	100%	86,309	3.9	3.9	1.9
1120	9.60	71%	124,124	9.0	6.4	2.9	15.17	98%	238,933	10.9	10.7	5.4
1121	13.42	100%	92,718	4.8	4.8	2.1	15.42	100%	115,219	5.2	5.2	2.6
1122	13.42	100%	65,575	3.4	3.4	1.5	15.42	100%	88,632	4.0	4.0	2.0
1123	5.90	44%	5,173	0.6	0.3	0.1	10.75	69%	9,744	0.6	0.4	0.2
1124	0.00	0%	0	0.0	0.0	0.0	0.00	0%	0	0.0	0.0	0.0
1125	13.41	100%	80,650	4.2	4.2	1.9	15.42	100%	100,136	4.5	4.5	2.2
		total gallons	1,952,157						2,556,530			
		operating q gpm	100.7						114.7			
		days/month	30						31			
		avg monthly q gpm	45						57			
			avg well q gpm	4.2	4.0	1.8				4.7	4.6	2.3
	Nov-04						Dec-04					
	Total Time On	23.31	days	q1	q2	q3	Total Time On	24.23	days	q1	q2	q3
Well	Total Time	OST	Gallons	gpm	gpm	gpm	Total Time	OST	Gallons	gpm	gpm	gpm
1101	23.25	100%	203,946	6.1	6.1	4.7	24.15	100%	204,056	5.9	5.8	4.6
1102	23.25	100%	171,778	5.1	5.1	4.0	24.15	100%	172,369	5.0	4.9	3.9
1103	23.26	100%	215,886	6.4	6.4	5.0	24.15	100%	222,418	6.4	6.4	5.0
1104	23.24	100%	150,253	4.5	4.5	3.5	24.15	100%	145,489	4.2	4.2	3.3
1105	23.25	100%	173,744	5.2	5.2	4.0	24.15	100%	174,313	5.0	5.0	3.9
1106	23.25	100%	81,430	2.4	2.4	1.9	24.15	100%	77,515	2.2	2.2	1.7

TUBA CITY EXTRACTION WELL OPERATIONAL SUMMARY: MARCH 2004 THROUGH MARCH 2005												
1107	23.25	100%	132,224	3.9	3.9	3.1	24.15	100%	133,364	3.8	3.8	3.0
1108	23.13	99%	166,931	5.0	5.0	3.9	24.15	100%	172,253	5.0	4.9	3.9
1109	23.25	100%	89,642	2.7	2.7	2.1	24.15	100%	83,802	2.4	2.4	1.9
1110	23.17	99%	127,371	3.8	3.8	2.9	23.80	98%	124,826	3.6	3.6	2.8
1111	23.25	100%	126,853	3.8	3.8	2.9	24.15	100%	126,452	3.6	3.6	2.8
1112	22.47	96%	76,490	2.4	2.3	1.8	23.53	97%	71,915	2.1	2.1	1.6
1113	14.51	62%	52,869	2.5	1.6	1.2	18.40	76%	62,667	2.4	1.8	1.4
1114	23.25	100%	155,525	4.6	4.6	3.6	24.15	100%	157,076	4.5	4.5	3.5
1115	23.25	100%	192,316	5.7	5.7	4.5	24.15	100%	197,158	5.7	5.7	4.4
1116	23.25	100%	133,356	4.0	4.0	3.1	24.15	100%	136,383	3.9	3.9	3.1
1117	23.25	100%	240,336	7.2	7.2	5.6	24.15	100%	248,614	7.1	7.1	5.6
1118	23.18	99%	132,592	4.0	4.0	3.1	24.15	100%	138,874	4.0	4.0	3.1
1119	23.25	100%	111,068	3.3	3.3	2.6	24.15	100%	104,490	3.0	3.0	2.3
1120	15.83	68%	195,579	8.6	5.8	4.5	15.17	63%	177,313	8.1	5.1	4.0
1121	23.22	100%	160,271	4.8	4.8	3.7	24.05	99%	162,598	4.7	4.7	3.6
1122	23.26	100%	112,183	3.3	3.3	2.6	24.15	100%	109,936	3.2	3.2	2.5
1123	9.85	42%	8,436	0.6	0.3	0.2	10.86	45%	8,886	0.6	0.3	0.2
1124	0.00	0%	0	0.0	0.0	0.0	0.00	0%	0	0.0	0.0	0.0
1125	23.26	100%	137,836	4.1	4.1	3.2	24.15	100%	141,310	4.1	4.1	3.2
		total gallons	3,348,914						3,354,076			
		operating q gpm	99.8						96.1			
		days/month	30						31			
		avg monthly q gpm	78						75			
		avg well q gpm		4.2	4.0	3.1				4.0	3.8	3.0
	Jan-05						Feb-05					
	Total Time On	27.55 days		q1	q2	q3	Total Time On	24.98 days		q1	q2	q3
Well	Total Time	OST	Gallons	gpm	gpm	gpm	Total Time	OST	Gallons	gpm	gpm	gpm
1101	27.46	100%	230,448	5.8	5.8	5.3	15.69	63%	124,621	5.5	3.5	3.1
1102	27.46	100%	192,551	4.9	4.9	4.5	24.91	100%	170,022	4.7	4.7	4.2
1103	27.46	100%	253,131	6.4	6.4	5.9	24.91	100%	228,914	6.4	6.4	5.7
1104	27.47	100%	162,336	4.1	4.1	3.8	24.91	100%	144,596	4.0	4.0	3.6
1105	27.45	100%	248,236	6.3	6.3	5.7	24.91	100%	231,318	6.4	6.4	5.7
1106	27.47	100%	82,990	2.1	2.1	1.9	24.91	100%	71,908	2.0	2.0	1.8
1107	27.46	100%	150,142	3.8	3.8	3.5	24.92	100%	134,706	3.8	3.7	3.3
1108	27.43	100%	194,600	4.9	4.9	4.5	24.90	100%	176,173	4.9	4.9	4.4
1109	27.46	100%	94,891	2.4	2.4	2.2	24.91	100%	81,176	2.3	2.3	2.0
1110	26.96	98%	137,199	3.5	3.5	3.2	24.42	98%	123,618	3.5	3.4	3.1
1111	27.46	100%	138,956	3.5	3.5	3.2	24.91	100%	123,607	3.4	3.4	3.1
1112	27.38	99%	77,410	2.0	2.0	1.8	24.86	100%	68,846	1.9	1.9	1.7
1113	25.31	92%	80,040	2.2	2.0	1.9	24.25	97%	76,242	2.2	2.1	1.9
1114	27.46	100%	174,551	4.4	4.4	4.0	24.91	100%	162,478	4.5	4.5	4.0
1115	27.47	100%	222,278	5.6	5.6	5.1	24.91	100%	209,648	5.8	5.8	5.2
1116	27.46	100%	154,833	3.9	3.9	3.6	24.91	100%	143,992	4.0	4.0	3.6
1117	27.46	100%	280,851	7.1	7.1	6.5	3.49	14%	19,812	3.9	0.6	0.5
1118	27.46	100%	157,045	4.0	4.0	3.6	24.91	100%	151,328	4.2	4.2	3.8
1119	27.46	100%	116,810	3.0	2.9	2.7	24.91	100%	105,532	2.9	2.9	2.6
1120	16.56	60%	189,720	8.0	4.8	4.4	14.70	59%	166,071	7.8	4.6	4.1
1121	27.42	100%	184,842	4.7	4.7	4.3	24.87	100%	165,560	4.6	4.6	4.1
1122	27.46	100%	121,966	3.1	3.1	2.8	24.91	100%	108,926	3.0	3.0	2.7
1123	14.64	53%	11,697	0.6	0.3	0.3	14.95	60%	10,798	0.5	0.3	0.3
1124	0.00	0%	0	0.0	0.0	0.0	12.03	48%	91,372	5.3	2.5	2.3
1125	26.47	96%	159,392	4.2	4.0	3.7	24.91	100%	136,625	3.8	3.8	3.4
		total gallons	3,816,916						3,227,888			
		operating q gpm	96.2						89.7			
		days/month	30						28			
		avg monthly q gpm	88						80			
		avg well q gpm		4.0	3.8	3.5				4.1	3.6	3.2
	Mar-05											
	Total Time On	30.54 days		q1	q2	q3						
Well	Total Time	OST	Gallons	gpm	gpm	gpm						
1101	27.90	91%	271,428	6.8	6.2	6.1						
1102	30.34	99%	191,512	4.4	4.4	4.3						
1103	30.45	100%	277,772	6.3	6.3	6.2						
1104	30.45	100%	166,811	3.8	3.8	3.7						
1105	30.45	100%	274,606	6.3	6.2	6.2						
1106	30.45	100%	80,668	1.8	1.8	1.8						
1107	30.45	100%	160,017	3.6	3.6	3.6						
1108	30.45	100%	209,306	4.8	4.8	4.7						
1109	30.45	100%	93,320	2.1	2.1	2.1						
1110	29.91	98%	143,714	3.3	3.3	3.2						
1111	30.45	100%	145,536	3.3	3.3	3.3						
1112	30.45	100%	76,716	1.7	1.7	1.7						

Table A−2 (continued). Extraction Well Operation Summary—March 2004 through March 2005

TUBA CITY EXTRACTION WELL OPERATIONAL SUMMARY: MARCH 2004 THROUGH MARCH 2005						
1113	29.85	98%	78,659	1.8	1.8	1.8
1114	30.45	100%	190,799	4.4	4.3	4.3
1115	30.45	100%	249,497	5.7	5.7	5.6
1116	30.45	100%	170,174	3.9	3.9	3.8
1117	29.51	97%	129,734	3.1	2.9	2.9
1118	30.46	100%	177,878	4.1	4.0	4.0
1119	30.45	100%	126,071	2.9	2.9	2.8
1120	16.66	55%	173,492	7.2	3.9	3.9
1121	30.45	100%	194,309	4.4	4.4	4.4
1122	30.45	100%	121,113	2.8	2.8	2.7
1123	14.94	49%	9,845	0.5	0.2	0.2
1124	30.45	100%	220,324	5.0	5.0	4.9
1125	30.37	99%	144,378	3.3	3.3	3.2
		total gallons	4,077,677			
		operating q gpm	92.7			
		days/month	31			
		avg monthly q gpm	91			
		avg well q gpm		3.9	3.7	3.7
total time on = number of days in month that pumps are operating						
total time = number of days in month of pump on-cycle; excludes off-cycle time						
ost (on stream time) = total time on / total time						
q1 = instantaneous pumping rate						
q2 = effective pumping rate on-cycle plus off-cycle time						
q3 = effective pumping rate during month						

Appendix B

Ground Water Sample Results for February 2004 and the Baseline Period for Contaminants Requiring Remediation

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Table B−1. Baseline, August 2004 and February 2005 Molybdenum Concentrations

Well Number	Horizon	Baseline Molybdenum Concentration (mg/L)	Year Sampled, Baseline	Aug 2004 Molybdenum Concentration (mg/L)	Feb 2005 Molybdenum Concentration (mg/L)
0284	A			NS	Dry
0285	A			NS	Dry
0686	A	0.0015U	2002	0.0014	0.0011U
0687	A	0.0113	2002	0.0017	0.0015
0688	A	0.0015U	2002	0.0029	0.0016
0901	A	0.00078	2001	0.00065BU	0.00054BU
0906	A	0.0137	2002	0.028	0.017
0929	A	0.0015U	2002	0.00047BU	0.00046BU
0940	A	0.0015U	2002	NS	NS
0941	A	0.0284	2002	0.063	0.021
0945	A	0.0015U	2002	0.0011	NS
0946	A			0.0025	0.0024
000I	B			NS	NS
0262	B	0.432	2001	0.58	0.64
0263	B	0.192	2001	0.059	0.042
0265	B	0.00046	2001	0.00064BU	0.00047BU
0267	B	0.0015U	2002	0.00053BU	0.00041BU
0271	B	0.0015U	2002	0.00041BU	NS
0281	B			NS	0.0031
0282	B			NS	0.0048
0283	B			NS	0.003
0908	B	0.0015U	2002	0.0004BU	0.00044BU
0909	B	0.0015U	2002	0.00049BU	0.00032BU
0910	B			NS	0.00052BU
0918	B			NS	NS
0934	B	0.0015U	2002	0.00038BU	0.00035BU
0935	B	0.0015U	2002	NS	NS
0936	B	0.0015U	2002	0.0013	0.0012U
0938	B	0.001U	1999	NS	NS
0942	B	0.021	2002	0.025	0.018
0943	B	0.0015U	2002	0.0005BU	0.00035BU
0947	B	0.0015U	2002	NS	NS
1126	B			NS	NS
1127	B			NS	NS
1128	B			NS	NS
1129	B			NS	NS
1130	B			NS	NS
1131	B			NS	NS
1132	B			NS	NS
1133	B			NS	NS
0274	C			NS	0.00058BU
0276	C			NS	0.00063BU
0279	C			NS	0.0038
0280	C			NS	0.00063BU
0683	C	0.0015U	2002	0.00066BU	NS
0684	C	0.0015U	2002	0.00077BU	NS

Table B−1 (continued). Baseline, August 2004 and February 2005 Molybdenum Concentrations

Well Number	Horizon	Baseline Molybdenum Concentration (mg/L)	Year Sampled, Baseline	Aug 2004 Molybdenum Concentration (mg/L)	Feb 2005 Molybdenum Concentration (mg/L)
0685	C	0.0015U	2002	0.00054BU	NS
0689	C	0.0015U	2002	0.00049BU	NS
0691	C	0.0015U	2002	0.00035BU	0.0004BU
0903	C	0.0015U	2002	0.00053BU	0.00045BU
0912	C	0.0003U	2001	0.00044BU	NS
0914	C	0.00081	2001	0.00078BU	NS
0917	C	0.0013	2001	NS	0.00057BU
0930	C	0.0015U	2002	0.00037BU	0.00035BU
0932	C	0.0018U	2002	0.0014	0.00063BU
1008	C	0.0004U	2000	NS	0.0005BU
1116	C	0.0015U	2002	0.00033BU	NS
1117	C	0.0015U	2002	0.00034BU	NS
1118	C	0.0015U	2002	NS	NS
0258	D	0.00063	2000	NS	0.00053BU
0261	D	0.0026	2001	0.00069BU	NS
0264	D	0.0031	2001	0.00077BU	0.00052BU
0266	D	0.00058	2001	0.00054BU	0.00049BU
0272	D			NS	0.00038BU
0273	D			NS	0.027
0275	D			NS	0.0006BU
0277	D			NS	0.0016
0278	D			NS	0.00053BU
0690	D	0.0015U	2002	0.00069BU	0.00056BU
0692	D	0.0015U	2002	0.00063B	0.00055BU
0695	D	0.0015U	2002	0.00068BU	NS
0904	D	0.00077	2001	NS	0.0006BU
0915	D	0.00054	2001	NS	NS
1003	D	0.0004U	2000	NS	0.00034BU
1004	D	0.0004U	2000	0.00051BU	0.00046BU
1005	D	0.0004U	2000	NS	NS
1006	D	0.0004U	2000	NS	0.0004BU
1007	D	0.0004U	2000	NS	0.00035BU
1101	D	0.0015U	2002	0.00058BU	NS
1102	D	0.0015U	2002	0.00042BU	NS
1103	D	0.0015U	2002	0.00098BU	NS
1104	D	0.0916	2002	0.043	NS
1105	D	2.96	2002	1.5	NS
1106	D	1.26	2002	0.44	NS
1107	D	0.16	2002	0.014	NS
1108	D	0.0015U	2002	0.00045BU	NS
1109	D	0.0015U	2002	0.00038BU	NS
1110	D	0.0015U	2002	0.00098BU	NS
1111	D	0.0015U	2002	0.00029BU	NS
1112	D	0.0015U	2002	0.00037BU	NS
1113	D	0.0015U	2002	0.00036BU	NS
1114	D	0.0027	2002	0.00099BU	NS

Table B−1 (continued). Baseline, August 2004 and February 2005 Molybdenum Concentrations

Well Number	Horizon	Baseline Molybdenum Concentration (mg/L)	Year Sampled, Baseline	Aug 2004 Molybdenum Concentration (mg/L)	Feb 2005 Molybdenum Concentration (mg/L)
1115	D	0.0015U	2002	0.00038BU	NS
1119	D	0.0053	2002	0.00082BU	NS
1120	D	0.0815	2002	0.025	NS
1121	D	0.105	2002	0.039	NS
1122	D	0.0015U	2002	0.00068BU	NS
1123	D	0.0015U	2002	NS	NS
1124	D	0.0015U	2002	NS	NS
1125	D	0.0015U	2002	0.00048BU	NS
0251	E	0.0015U	2002	0.00054BU	0.00044BU
0268	E	0.0015U	2002	0.00084BU	0.00051BU
0920	E	0.0003U	2001	NS	0.00049BU
0911	F			NS	0.00039BU
0913	G	0.0003U	2001	0.00038BU	NS
0916	G	0.00096	2001	NS	NS
0919	G			NS	0.00074BU
0902	H			NS	NS
0252	I	0.0015U	2002	0.00082BU	0.00036BU
0254	I	0.164	2002	0.059	0.055
0256	I	0.0015U	2002	0.00099BU	0.00055BU
0921	I	0.0003U	2001	NS	0.00037BU
0255	M	0.0043	2000	0.059	0.071
0257	M	0.00041	2000	0.042U	0.044

B=Result is between the IDL and CRDL
NS=Not sampled
U=Analytical result below detection limit

Table B−2. Baseline, August 2004 and February 2005 Nitrate Concentrations

Well Number	Horizon	Baseline Nitrate Concentration (mg/L)	Year Sampled, Baseline	Aug 2004 Nitrate Concentration (mg/L)	Feb 2005 Nitrate Concentration (mg/L)
0284	A			NS	Dry
0285	A			NS	Dry
0686	A	32.2	2002	16	16
0687	A	60.6	2002	7.5	12
0688	A	35.1	2002	39	43
0901	A	13	2001	14	14
0906	A	1470	2002	1510	1590
0929	A	69.5	2002	71	62
0940	A	1800	2002	NS	NS
0941	A	358	2002	576	708
0945	A	12.7	2002	12	NS
0946	A			23	25
000I	B			NS	NS
0262	B	380	2001	487	487
0263	B	1140	2001	841	753
0265	B	720	2001	430	487
0267	B	1640	2002	1550	1510
0271	B	15.6	2002	16	NS
0281	B			NS	89
0282	B			NS	487
0283	B			NS	420
0908	B	651	2002	664	664
0909	B	485	2002	531	576
0910	B			NS	10
0918	B			NS	NS
0934	B	2320	2002	2260	2170
0935	B	525	2002	NS	615
0936	B	2950	2002	2120	2430
0938	B	1450	1999	NS	NS
0942	B	1360	2002	1460	1680
0943	B	22.1	2002	330	210
0947	B	12.5	2002	NS	NS
1126	B			NS	1143
1127	B			NS	400
1128	B			NS	411
1129	B			NS	578
1130	B			NS	1179
1131	B			NS	1535
1132	B			NS	1203
1133	B			NS	692
0274	C			NS	15
0276	C			NS	14
0279	C			NS	28
0280	C			NS	10
0683	C	14.1	2002	14	NS
0684	C	13.9	2002	14	NS

Table B−2 (continued). Baseline, August 2004 and February 2005 Nitrate Concentrations

Well Number	Horizon	Baseline Nitrate Concentration (mg/L)	Year Sampled, Baseline	Aug 2004 Nitrate Concentration (mg/L)	Feb 2005 Nitrate Concentration (mg/L)
0685	C	14.3	2002	10	NS
0689	C	14.3	2002	14	NS
0691	C	298	2002	170	200
0903	C	54.8	2002	49	42
0912	C	403	2001	280	NS
0914	C	13	2001	12	NS
0917	C	15.7	2001	NS	16
0930	C	50.9	2002	62	66
0932	C	25.3	2002	25	26
1008	C	15.7	2000	NS	14
1116	C	106	2002	89	109
1117	C	225	2002	340	NS
1118	C	164	2002	NS	588
0258	D	15	2000	NS	15
0261	D	14	2001	15	NS
0264	D	24.3	2001	40	38
0266	D	14	2001	15	15
0272	D			NS	17
0273	D			NS	190
0275	D			NS	1060
0277	D			NS	14
0278	D			NS	14
0690	D	12.5	2002	13	13
0692	D	12.5	2002	13	13
0695	D	25.4	2002	27	NS
0904	D	5.13	2001	NS	4
0915	D	14.1	2001	NS	NS
1003	D	176	2000	NS	220
1004	D	49.1	2000	21	44
1005	D	14.5	2000	NS	NS
1006	D	14.1	2000	NS	10
1007	D	15.3	2000	NS	15
1101	D	438	2002	443	485
1102	D	650	2002	620	601
1103	D	1120	2002	1020	1062
1104	D	993	2002	531	580
1105	D	648	2002	531	219
1106	D	614	2002	200	185
1107	D	1060	2002	210	178
1108	D	1410	2002	664	641
1109	D	798	2002	410	425
1110	D	227	2002	180	174
1111	D	421	2002	390	391
1112	D	617	2002	150	127
1113	D	143	2002	49	45
1114	D	228	2002	200	214

Table B−2 (continued). Baseline, August 2004 and February 2005 Nitrate Concentrations

Well Number	Horizon	Baseline Nitrate Concentration (mg/L)	Year Sampled, Baseline	Aug 2004 Nitrate Concentration (mg/L)	Feb 2005 Nitrate Concentration (mg/L)
1115	D	766	2002	290	284
1119	D	468	2002	487	534
1120	D	493	2002	270	228
1121	D	573	2002	210	195
1122	D	954	2002	270	226
1123	D	643	2002	NS	104
1124	D	781	2002	NS	NS
1125	D	104	2002	49	45
0251	E	426	2002	16	17
0268	E	15.4	2002	39	62
0920	E	14.8	2001	NS	15
0911	F			NS	10
0913	G	12.4	2001	12	NS
0916	G	11.6	2001	NS	NS
0919	G			NS	6.2
0902	H			NS	NS
0252	I	15.3	2002	10	11
0254	I	354	2002	440	487
0256	I	189	2002	39	49
0921	I	11	2001	NS	11
0255	M	9.6	2000	0.04U	0.04U
0257	M	6.9	2000	0.04U	0.04U

NS=Not sampled
U=Analytical result below detection limit

Table B−3. Baseline, August 2004 and February 2005 Selenium Concentrations

Well Number	Horizon	Baseline Selenium Concentration (mg/L)	Year Sampled, Baseline	Aug 2004 Selenium Concentration (mg/L)	Feb 2005 Selenium Concentration (mg/L)
0284	A			NS	Dry
0285	A			NS	Dry
0686	A	0.0088	2002	0.0051	0.0036
0687	A	0.0145	2002	0.0003	0.00046
0688	A	0.0033	2002	0.0057	0.015
0901	A	0.0024	2001	0.0021	0.0017
0906	A	0.0335	2002	0.02	0.017
0929	A	0.0028	2002	0.0022	0.0022
0940	A	0.105	2002	NS	NS
0941	A	0.0348	2002	0.048	0.055
0945	A	0.0035	2002	0.0031	NS
0946	A			0.0037	0.0047
000I	B			NS	NS
0262	B	0.0621	2001	0.061	0.065
0263	B	0.0632	2001	0.04	0.032
0265	B	0.0071	2001	0.0037	0.0036
0267	B	0.0532	2002	0.048	0.043
0271	B	0.0016	2002	0.0012	NS
0281	B			NS	0.00098
0282	B			NS	0.0035
0283	B			NS	0.0088
0908	B	0.0163	2002	0.022	0.023
0909	B	0.0224	2002	0.03	0.036
0910	B			NS	0.001
0918	B			NS	NS
0934	B	0.0116	2002	0.0089	0.0097
0935	B	0.0195	2002	NS	NS
0936	B	0.0869	2002	0.053	0.054
0938	B	0.0432	1999	NS	NS
0942	B	0.0348	2002	0.037	0.039
0943	B	0.0021	2002	0.01	0.0089
0947	B	0.0019	2002	NS	NS
1126	B			NS	
1127	B			NS	
1128	B			NS	
1129	B			NS	
1130	B			NS	
1131	B			NS	
1132	B			NS	
1133	B			NS	
0274	C			NS	0.0011
0276	C			NS	0.0012
0279	C			NS	0.00066
0280	C			NS	0.0016
0683	C	0.0022	2002	0.0015	NS
0684	C	0.0019	2002	0.0014	NS

Table B−3 (continued). Baseline, August 2004 and February 2005 Selenium Concentrations

Well Number	Horizon	Baseline Selenium Concentration (mg/L)	Year Sampled, Baseline	Aug 2004 Selenium Concentration (mg/L)	Feb 2005 Selenium Concentration (mg/L)
0685	C	0.0017	2002	0.0013	NS
0689	C	0.0014	2002	0.001	NS
0691	C	0.0046	2002	0.0019	0.0023
0903	C	0.0023	2002	0.0014	0.0013
0912	C	0.0137	2001	0.0083	NS
0914	C	0.0016	2001	0.00081	NS
0917	C	0.0017	2001	NS	0.00092
0930	C	0.002	2002	0.0017	0.0015
0932	C	0.0019	2002	0.0009	0.0011
1008	C	0.0015	2000	NS	0.00083
1116	C	0.0018	2002	0.0016	NS
1117	C	0.0028	2002	0.01	NS
1118	C	0.0028	2002	NS	NS
0258	D	0.0018	2000	NS	0.0012
0261	D	0.0021	2001	0.0012	NS
0264	D	0.0018	2001	0.0011	0.0012
0266	D	0.0013	2001	0.00086	0.00078
0272	D			NS	0.00082
0273	D			NS	0.016
0275	D			NS	0.021
0277	D			NS	0.001
0278	D			NS	0.00085
0690	D	0.0014	2002	0.001	0.00094
0692	D	0.0022	2002	0.0015	0.0014
0695	D	0.0019	2002	0.0015	NS
0904	D	0.0131	2001	NS	0.015
0915	D	0.0019	2001	NS	NS
1003	D	0.003	2000	NS	0.0025
1004	D	0.0021	2000	0.0018	0.0014
1005	D	0.0014	2000	NS	NS
1006	D	0.0013	2000	NS	0.00086
1007	D	0.0013	2000	NS	0.00088
1101	D	0.0188	2002	0.027	NS
1102	D	0.0121	2002	0.021	NS
1103	D	0.0613	2002	0.037	NS
1104	D	0.0344	2002	0.019	NS
1105	D	0.0871	2002	0.067	NS
1106	D	0.0925	2002	0.029	NS
1107	D	0.0903	2002	0.011	NS
1108	D	0.0704	2002	0.031	NS
1109	D	0.0372	2002	0.015	NS
1110	D	0.0081	2002	0.0058	NS
1111	D	0.0172	2002	0.016	NS
1112	D	0.0154	2002	0.0038	NS
1113	D	0.0025	2002	0.0011	NS
1114	D	0.0035	2002	0.0047	NS

Table B−3 (continued). Baseline, August 2004 and February 2005 Selenium Concentrations

Well Number	Horizon	Baseline Selenium Concentration (mg/L)	Year Sampled, Baseline	Aug 2004 Selenium Concentration (mg/L)	Feb 2005 Selenium Concentration (mg/L)
1115	D	0.0362	2002	0.0079	NS
1119	D	0.029	2002	0.017	NS
1120	D	0.0563	2002	0.023	NS
1121	D	0.0455	2002	0.017	NS
1122	D	0.0558	2002	0.017	NS
1123	D	0.0449	2002	NS	NS
1124	D	0.0186	2002	NS	NS
1125	D	0.0025	2002	0.0019	NS
0251	E	0.0035	2002	0.00071	0.00067
0268	E	0.0018	2002	0.0012	0.0013
0920	E	0.0014	2001	NS	0.00095
0911	F			NS	0.0007
0913	G	0.00063	2001	0.00047	NS
0916	G	0.001	2001	NS	NS
0919	G			NS	0.00019
0902	H			NS	NS
0252	I	0.00092	2002	0.00056	0.00052
0254	I	0.0531	2002	0.046	0.04
0256	I	0.0031	2002	0.0008	0.00081
0921	I	0.00091	2001	NS	0.00059
0255	M	0.0011	2000	0.00027	0.000079B
0257	M	0.0013	2000	0.00017	0.000092B

B=Result is between the IDL and CRDL
NS=Not sampled

Table B−4. Baseline, August 2004 and February 2005 Sulfate Concentrations

Well Number	Horizon	Baseline Sulfate Concentration (mg/L)	Year Sampled, Baseline	Aug 2004 Sulfate Concentration (mg/L)	Feb 2005 Sulfate Concentration (mg/L)
0284	A			NS	Dry
0285	A			NS	Dry
0686	A	98.6	2002	120	110
0687	A	329	2002	19	35
0688	A	40	2002	110	230
0901	A	26.2	2001	31	30
0906	A	1660	2002	1700	1900
0929	A	28.1	2002	26	26
0940	A	7550	2002	NS	NS
0941	A	745	2002	710	890
0945	A	32.1	2002	34	NS
0946	A			94	100
000l	B			NS	NS
0262	B	931	2001	1000	1000
0263	B	1990	2001	1900	2100
0265	B	1520	2001	800	810
0267	B	3680	2002	3500	3700
0271	B	16.4	2002	16	NS
0281	B			NS	62
0282	B			NS	790
0283	B			NS	530
0908	B	2430	2002	2600	3000
0909	B	666	2002	590	680
0910	B			NS	16
0918	B			NS	NS
0934	B	7360	2002	2300	2300
0935	B	2690	2002	NS	2506
0936	B	4360	2002	2500	2700
0938	B	2120	1999	NS	NS
0942	B	3030	2002	2900	3000
0943	B	29	2002	520	390
0947	B	18.7	2002	NS	NS
1126	B			NS	3583
1127	B			NS	570
1128	B			NS	506
1129	B			NS	1308
1130	B			NS	1993
1131	B			NS	1931
1132	B			NS	1972
1133	B			NS	555
0274	C			NS	15
0276	C			NS	18
0279	C			NS	36
0280	C			NS	21
0683	C	21.6	2002	18	NS
0684	C	18	2002	17	NS

Table B−4 (continued). Baseline, August 2004 and February 2005 Sulfate Concentrations

Well Number	Horizon	Baseline Sulfate Concentration (mg/L)	Year Sampled, Baseline	Aug 2004 Sulfate Concentration (mg/L)	Feb 2005 Sulfate Concentration (mg/L)
0685	C	26.2	2002	16	NS
0689	C	13.7	2002	14	NS
0691	C	587	2002	330	340
0903	C	76.5	2002	61	51
0912	C	846	2001	560	NS
0914	C	15.6	2001	15	NS
0917	C	13.9	2001	NS	15
0930	C	59.8	2002	70	80
0932	C	30.2	2002	26	26
1008	C	13	2000	NS	13
1116	C	176	2002	99	139
1117	C	255	2002	690	NS
1118	C	163	2002	NS	1488
0258	D	17.4	2000	NS	17
0261	D	18.2	2001	20	NS
0264	D	37.7	2001	59	56
0266	D	10.9	2001	11	11
0272	D			NS	12
0273	D			NS	210
0275	D			NS	2100
0277	D			NS	23
0278	D			NS	14
0690	D	13.8	2002	13	13
0692	D	20.8	2002	19	20
0695	D	50.4	2002	54	NS
0904	D	96.5	2001	NS	120
0915	D	17.8	2001	NS	NS
1003	D	302	2000	NS	410
1004	D	66.2	2000	31	68
1005	D	12.7	2000	NS	NS
1006	D	12.2	2000	NS	13
1007	D	11.7	2000	NS	12
1101	D	960	2002	1200	1303
1102	D	1320	2002	1300	1267
1103	D	2570	2002	2000	2007
1104	D	1870	2002	950	978
1105	D	1590	2002	1200	484
1106	D	1050	2002	420	356
1107	D	1200	2002	250	217
1108	D	3400	2002	1700	1521
1109	D	3280	2002	1100	1151
1110	D	512	2002	340	340
1111	D	988	2002	890	1021
1112	D	1140	2002	200	190
1113	D	136	2002	38	37
1114	D	328	2002	280	333

Table B−4 (continued). Baseline, August 2004 and February 2005 Sulfate Concentrations

Well Number	Horizon	Baseline Sulfate Concentration (mg/L)	Year Sampled, Baseline	Aug 2004 Sulfate Concentration (mg/L)	Feb 2005 Sulfate Concentration (mg/L)
1115	D	1930	2002	400	448
1119	D	1560	2002	870	1068
1120	D	2330	2002	1300	1166
1121	D	2590	2002	1400	1560
1122	D	2960	2002	1000	903
1123	D	1240	2002	NS	207
1124	D	1170	2002	NS	NS
1125	D	165	2002	76	69
0251	E	617	2002	13	14
0268	E	17.4	2002	55	99
0920	E	12.7	2001	NS	13
0911	F			NS	8.8
0913	G	8.43	2001	8.2	NS
0916	G	13.5	2001	NS	NS
0919	G			NS	3.6
0902	H			NS	NS
0252	I	19.2	2002	6.6	6.8
0254	I	505	2002	530	560
0256	I	368	2002	68	84
0921	I	8.52	2001	NS	7.6
0255	M	102	2000	4100	4400
0257	M	13.4	2000	340	370

NS=Not sampled

Table B−5. Baseline, August 2004 and February 2005 Uranium Concentrations

Well Number	Horizon	Baseline Uranium Concentration (mg/L)	Year Sampled, Baseline	Aug 2004 Uranium Concentration (mg/L)	Feb 2005 Uranium Concentration (mg/L)
0284	A			NS	Dry
0285	A			NS	Dry
0686	A	0.0021	2002	0.0007E	0.0003
0687	A	0.0208	2002	0.000046B	0.000039BU
0688	A	0.002	2002	0.0016	0.0012
0901	A	0.0026	2001	0.0023	0.0023
0906	A	0.951	2002	0.89	0.83
0929	A	0.0012	2002	0.00098	0.001
0940	A	0.546	2002	NS	NS
0941	A	0.0886	2002	0.076	0.049
0945	A	0.0031	2002	0.0034	NS
0946	A			0.00022	0.00016
0262	B	0.379	2001	0.53	0.56
0263	B	0.485	2001	0.23	0.19
0265	B	0.0897	2001	0.045	0.045
0267	B	0.0731	2002	0.088	0.085
0271	B	0.0014	2002	0.0012	NS
0281	B			NS	0.0061
0282	B			NS	0.054
0283	B			NS	0.027
0908	B	0.122	2002	0.12	0.11
0909	B	0.0389	2002	0.029	0.035
0910	B			NS	0.00076
0918	B			NS	NS
0934	B	0.312	2002	0.32	0.28
0935	B	0.0868	2002	NS	0.111
0936	B	0.267	2002	0.47	0.47
0938	B	0.21	1999	NS	NS
0942	B	0.246	2002	0.27	0.27
0943	B	0.0049	2002	0.2	0.2
0947	B	0.0024	2002	NS	NS
1126	B			NS	0.069
1127	B			NS	0.027
1128	B			NS	0.035
1129	B			NS	0.643
1130	B			NS	0.2606
1131	B			NS	0.472
1132	B			NS	1.477
1133	B			NS	0.0665
0274	C			NS	0.001
0276	C			NS	0.0013
0279	C			NS	0.0025
0280	C			NS	0.0011
0683	C	0.0012	2002	0.00091	NS
0684	C	0.0019	2002	0.001	NS
0685	C	0.0012	2002	0.00097	NS

Table B−5 (continued). Baseline, August 2004 and February 2005 Uranium Concentrations

Well Number	Horizon	Baseline Uranium Concentration (mg/L)	Year Sampled, Baseline	Aug 2004 Uranium Concentration (mg/L)	Feb 2005 Uranium Concentration (mg/L)
0689	C	0.0011	2002	0.00086	NS
0691	C	0.0657	2002	0.03	0.031
0903	C	0.0022	2002	0.0018	0.0014
0912	C	0.0342	2001	0.025	NS
0914	C	0.0013	2001	0.00045	NS
0917	C	0.0013	2001	NS	0.00055
0930	C	0.0023	2002	0.0026	0.0026
0932	C	0.0016	2002	0.0012	0.00099
1008	C	0.001	2000	NS	0.00083
1116	C	0.0081	2002	0.0073	0.0093
1117	C	0.0151	2002	0.03	NS
1118	C	0.0098	2002	NS	0.066
0258	D	0.0018	2000	NS	0.00092
0261	D	0.0018	2001	0.00089	NS
0264	D	0.0033	2001	0.003	0.0027
0266	D	0.0019	2001	0.0012	0.0013
0272	D			NS	0.00095
0273	D			NS	0.056
0275	D			NS	0.44
0277	D			NS	0.0033
0278	D			NS	0.00084
0690	D	0.0018	2002	0.0014	0.0014
0692	D	0.0015	2002	0.0012	0.0011
0695	D	0.002	2002	0.0019	NS
0904	D	0.0044	2001	NS	0.0041
0915	D	0.0017	2001	NS	NS
1003	D	0.0205	2000	NS	0.029
1004	D	0.0053	2000	0.0025	0.0072
1005	D	0.0013	2000	NS	NS
1006	D	0.0014	2000	NS	0.00073
1007	D	0.0012	2000	NS	0.00083
1101	D	0.245	2002	0.32	0.369
1102	D	0.533	2002	0.45	0.398
1103	D	0.355	2002	0.44	0.391
1104	D	0.194	2002	0.12	0.12
1105	D	2.1	2002	1.5	0.578
1106	D	2.1	2002	0.76	0.543
1107	D	0.118	2002	0.041	0.037
1108	D	0.646	2002	0.23	0.218
1109	D	0.565	2002	0.26	0.275
1110	D	0.0528	2002	0.065	0.066
1111	D	0.161	2002	0.16	0.178
1112	D	0.13	2002	0.037	0.036
1113	D	0.0149	2002	0.004	0.0046
1114	D	0.0277	2002	0.028	0.032
1115	D	0.41	2002	0.05	0.053

Table B−5 (continued). Baseline, August 2004 and February 2005 Uranium Concentrations

Well Number	Horizon	Baseline Uranium Concentration (mg/L)	Year Sampled, Baseline	Aug 2004 Uranium Concentration (mg/L)	Feb 2005 Uranium Concentration (mg/L)
1119	D	0.555	2002	0.16	0.206
1120	D	1.3	2002	0.4	0.318
1121	D	0.857	2002	0.37	0.337
1122	D	0.878	2002	0.29	0.263
1123	D	0.261	2002	NS	0.041
1124	D	0.171	2002	NS	NS
1125	D	0.0176	2002	0.011	0.011
0251	E	0.0481	2002	0.0013	0.0012
0268	E	0.0014	2002	0.0077	0.015
0920	E	0.0017	2001	NS	0.00095
0911	F			NS	0.00085
0913	G	0.0016	2001	0.00091	NS
0916	G	0.0014	2001	NS	NS
0919	G			NS	0.000044BU
0902	H			NS	NS
0252	I	0.0024	2002	0.0015	0.0013
0254	I	0.209	2002	0.1	0.089
0256	I	0.0775	2002	0.0097	0.01
0921	I	0.0047	2001	NS	0.0046
0255	M	0.0029	2000	0.0019	0.0017
0257	M	0.0037	2000	0.018	0.018

B=Result is between the IDL and CRDL
E=Estimate value because of interference, see case narrative
NS=Not sampled
U=Analytical result below detection limit

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Appendix C

Monitor Well Water Level Hydrographs

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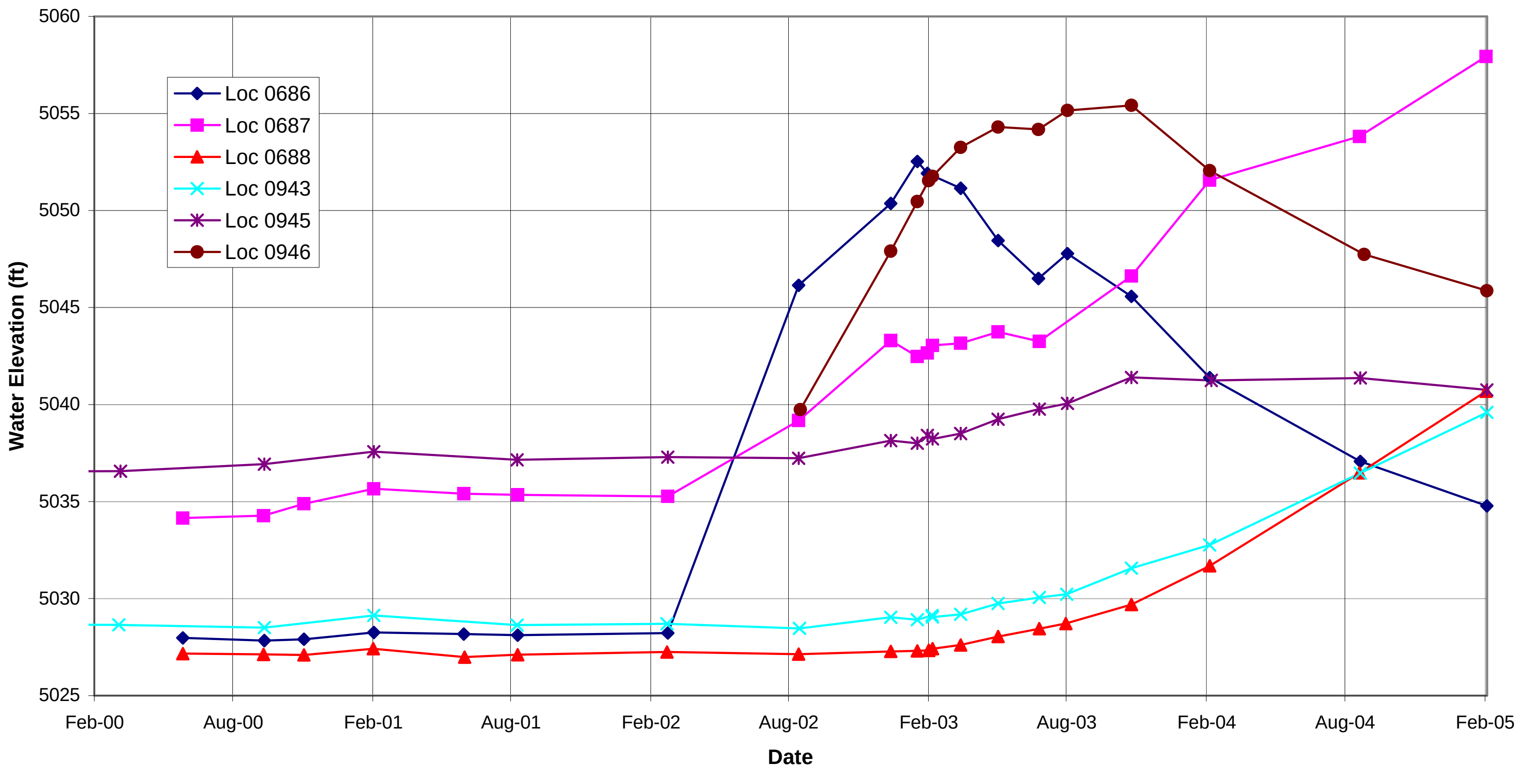

Figure C−1. Water Level Hydrographs: Monitor Wells at Infiltration Trench

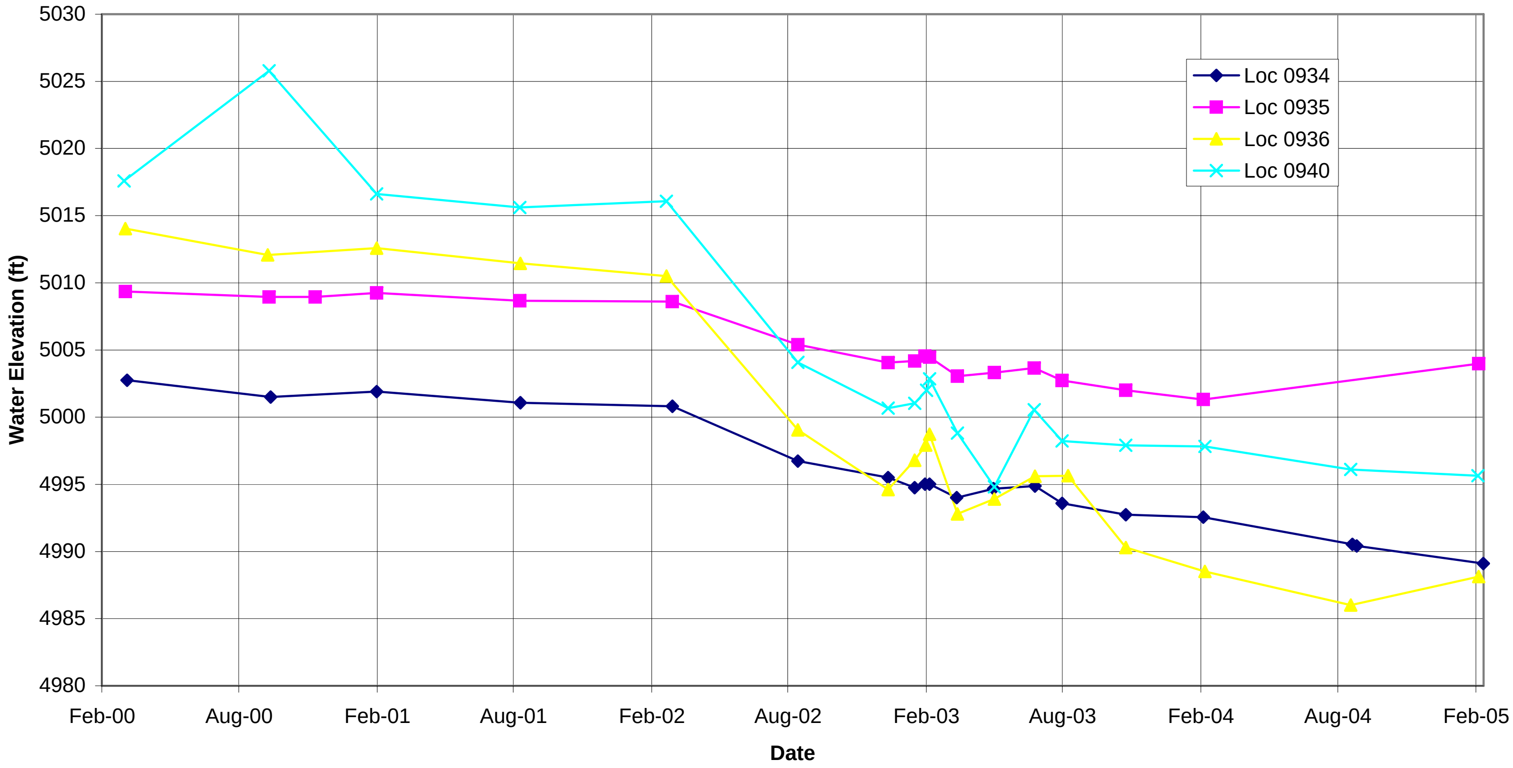

Figure C−2. Water Level Hydrographs: Selected Horizon A and B Monitor Wells

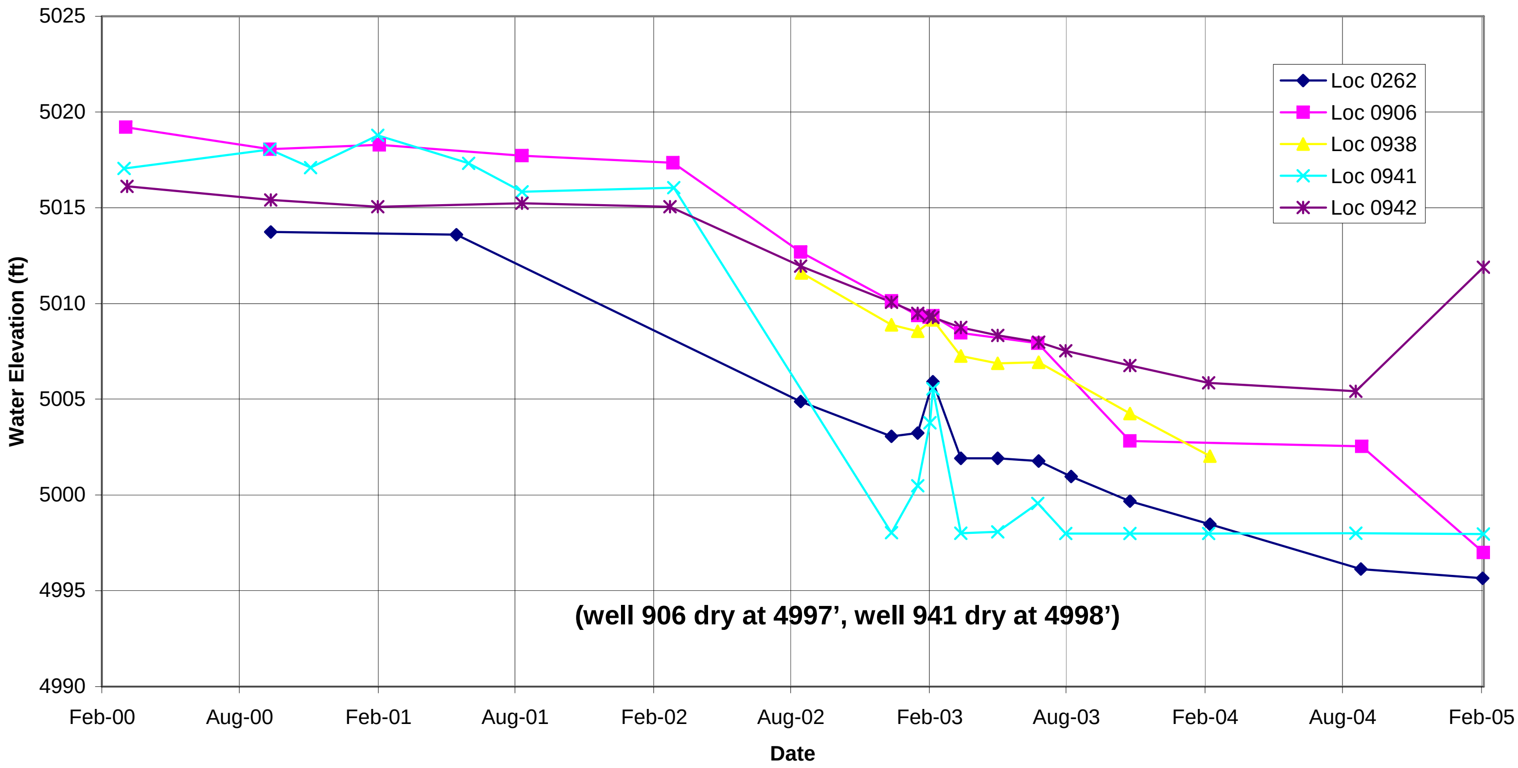

Figure C−3. Water Level Hydrographs: Selected Horizon A and B Monitoring Wells

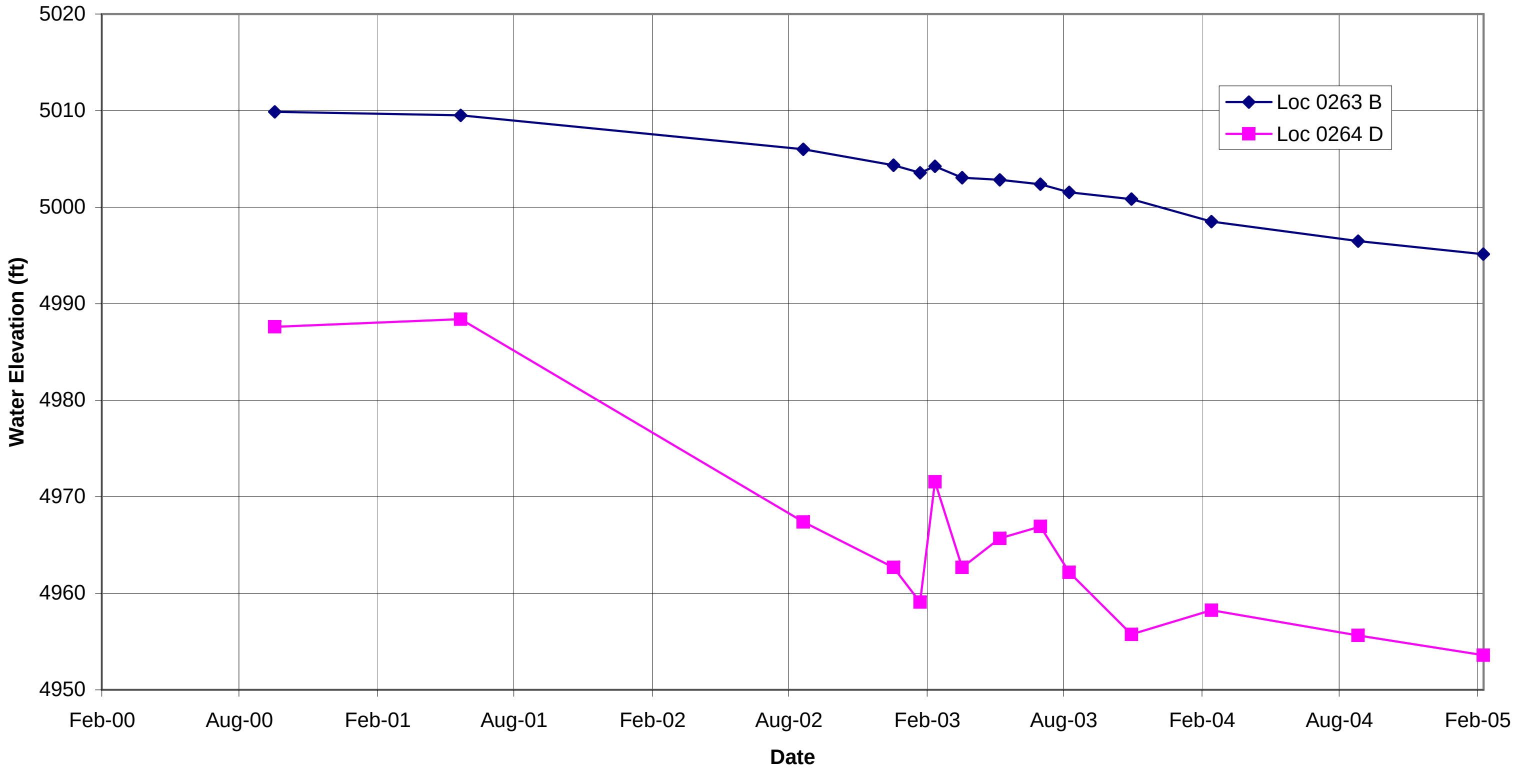

Figure C−4. Water Level Hydrographs: Middle Terrace Well Pair 263/264

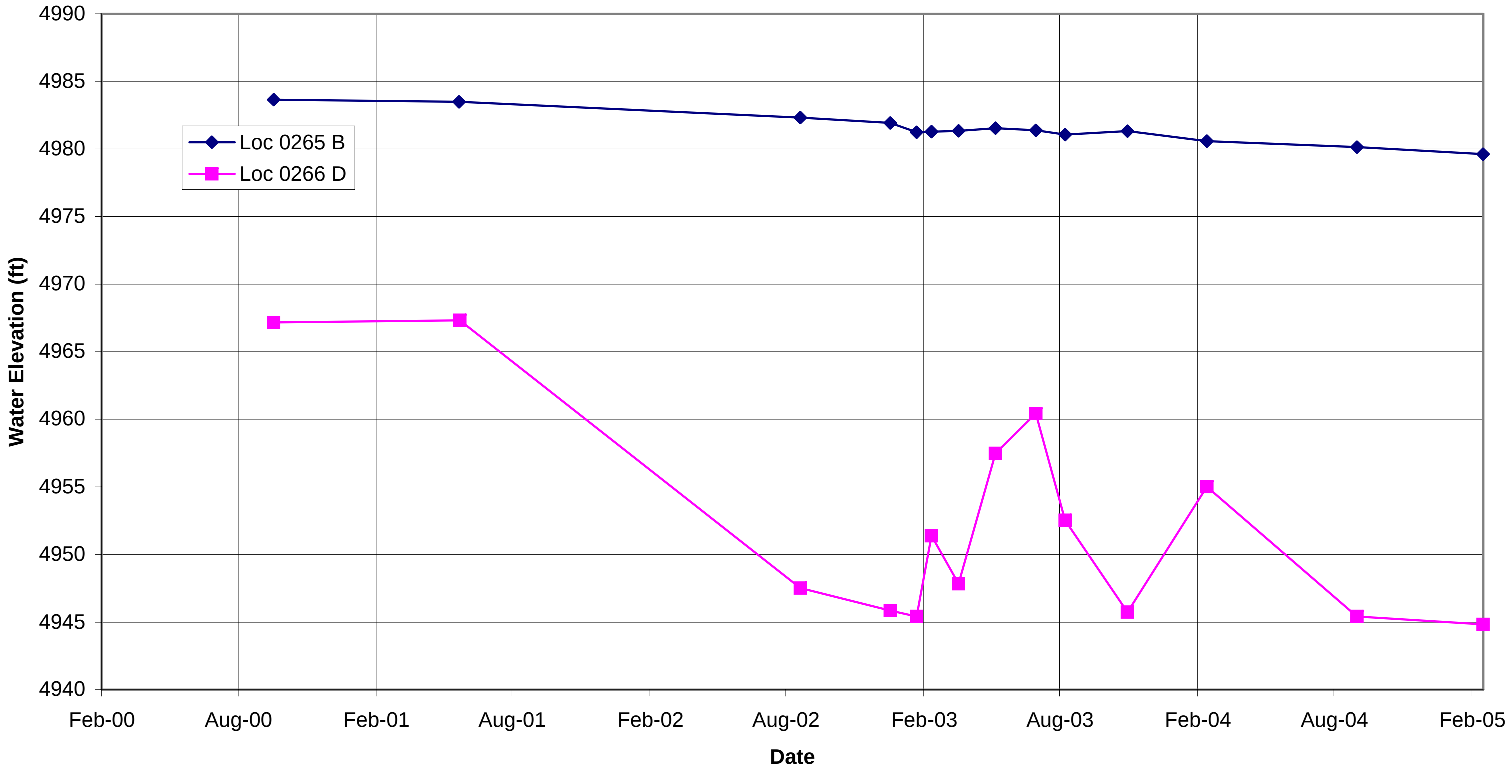

Figure C−5. Water Level Hydrographs: Middle Terrace Well Pair 265/266

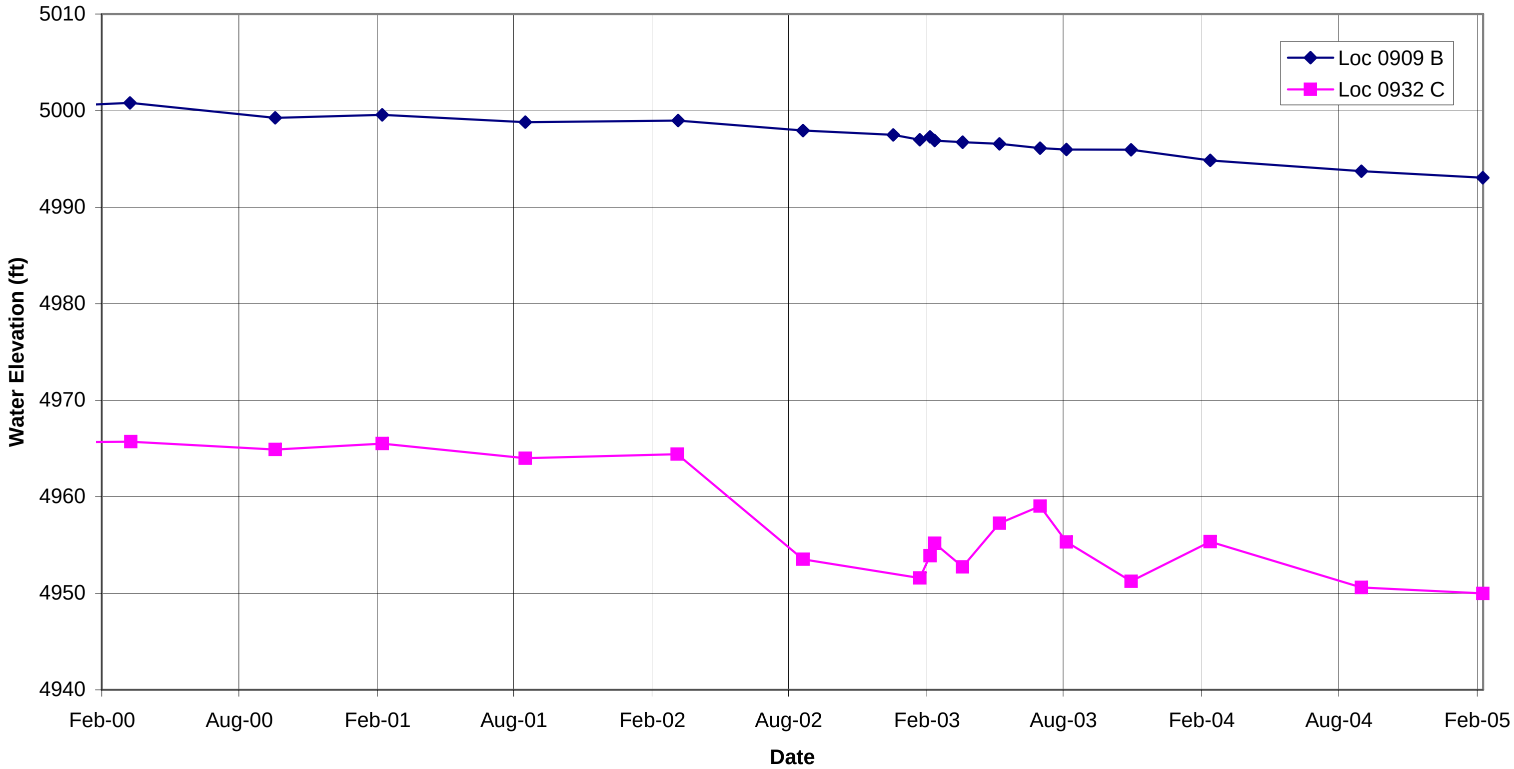

Figure C−6. Water Level Hydrographs: Middle Terrace Well Pair 909/932

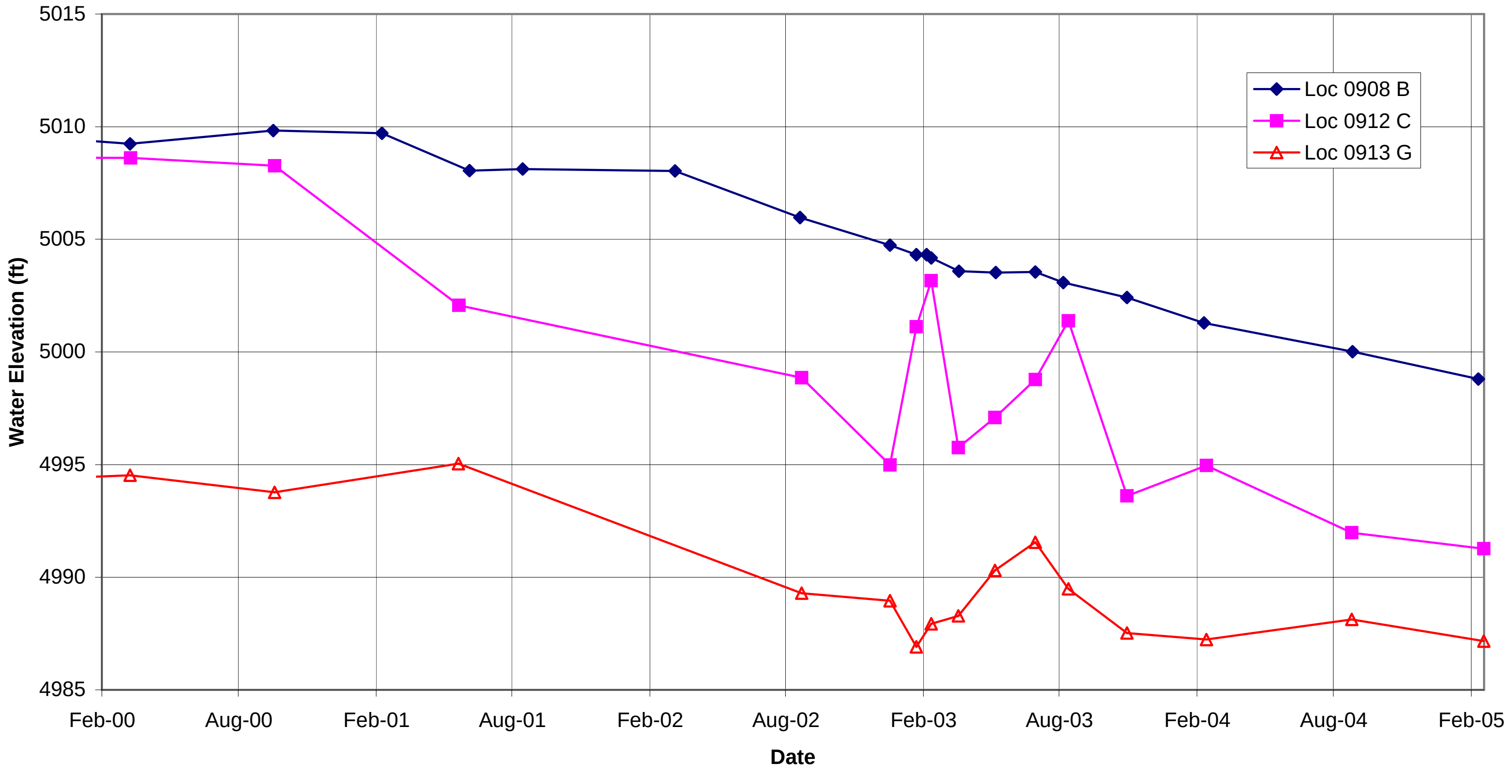

Figure C−7. Water Level Hydrographs: Middle Terrace Well Cluster 908/912/913

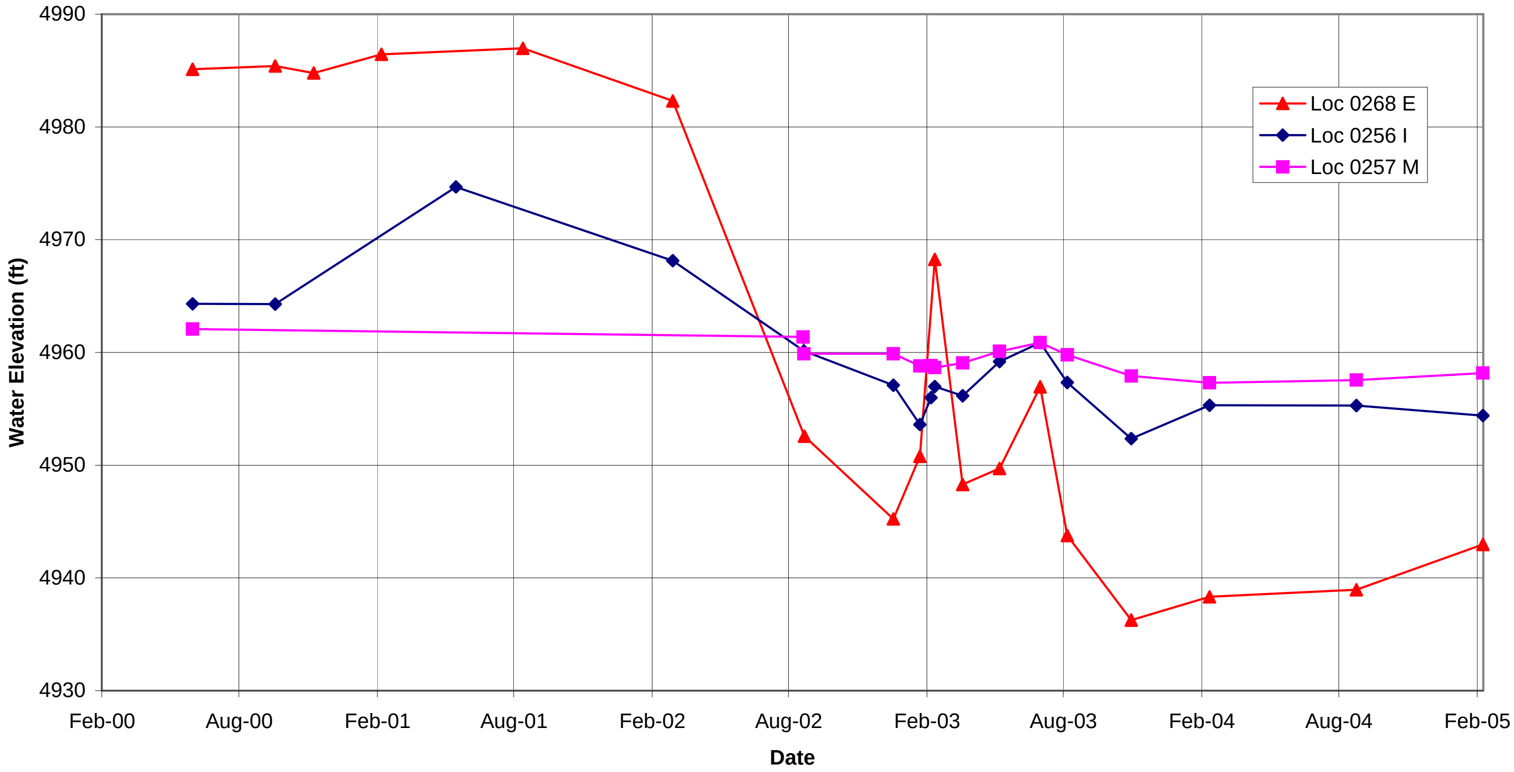

Figure C−8. Water Level Hydrographs: Middle Terrace Well Cluster 268/256/257

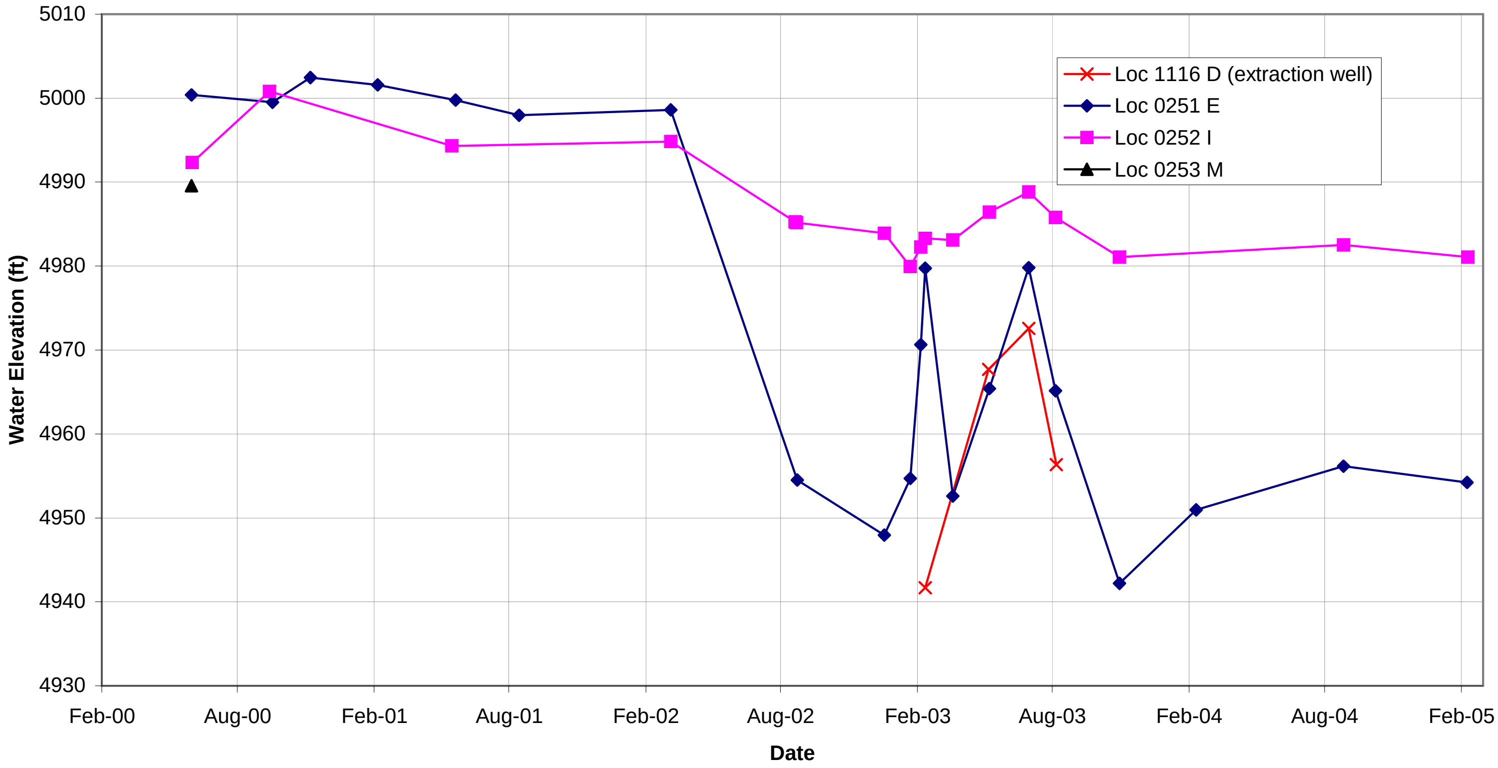

Figure C−9. Water Level Hydrographs: Middle Terrace Well Cluster 1116/251/252/253

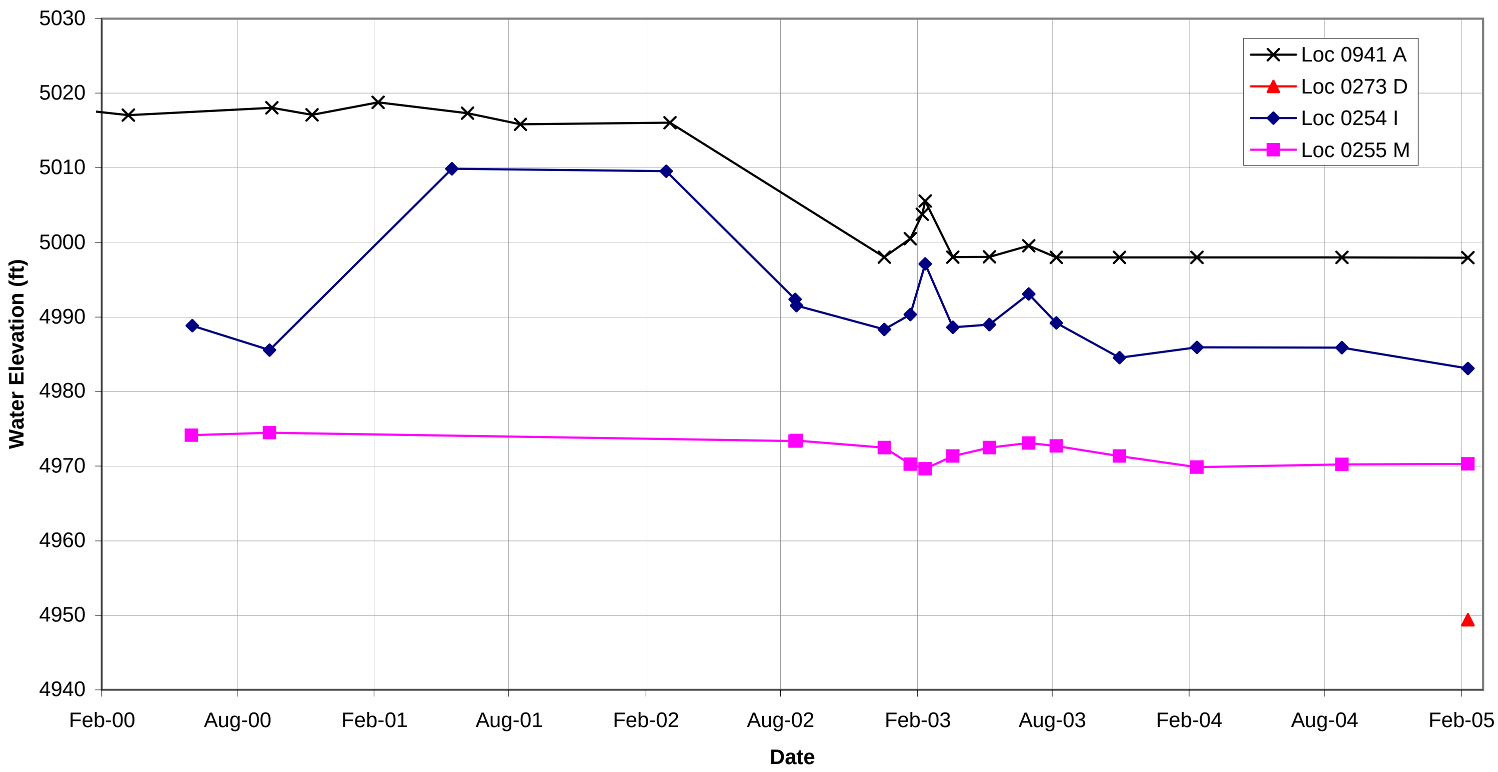

Figure C–10. Water Level Hydrographs: Middle Terrace Well Cluster 941/273/254/255

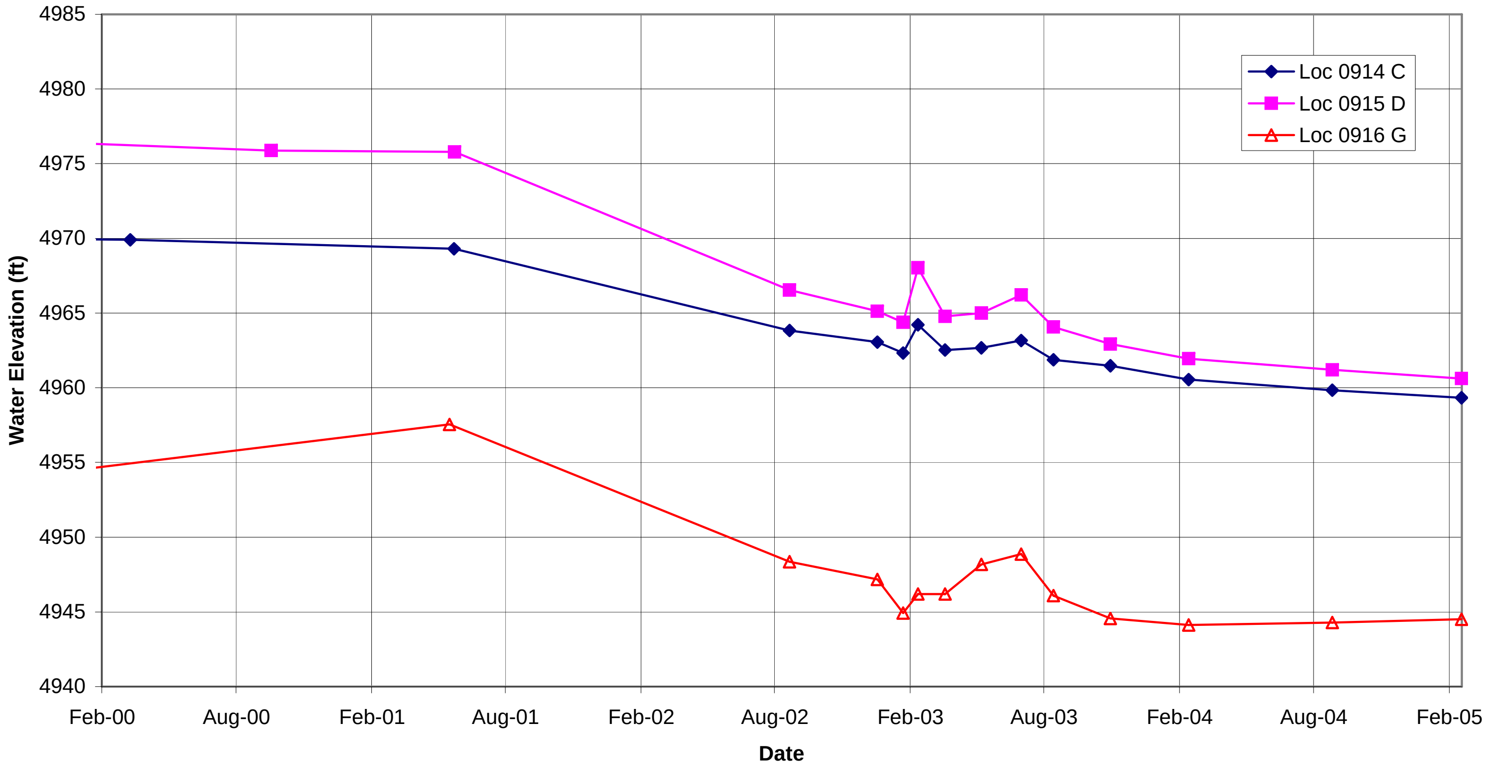

Figure C–11. Water Level Hydrographs: Middle Terrace Well Cluster 914/915/916

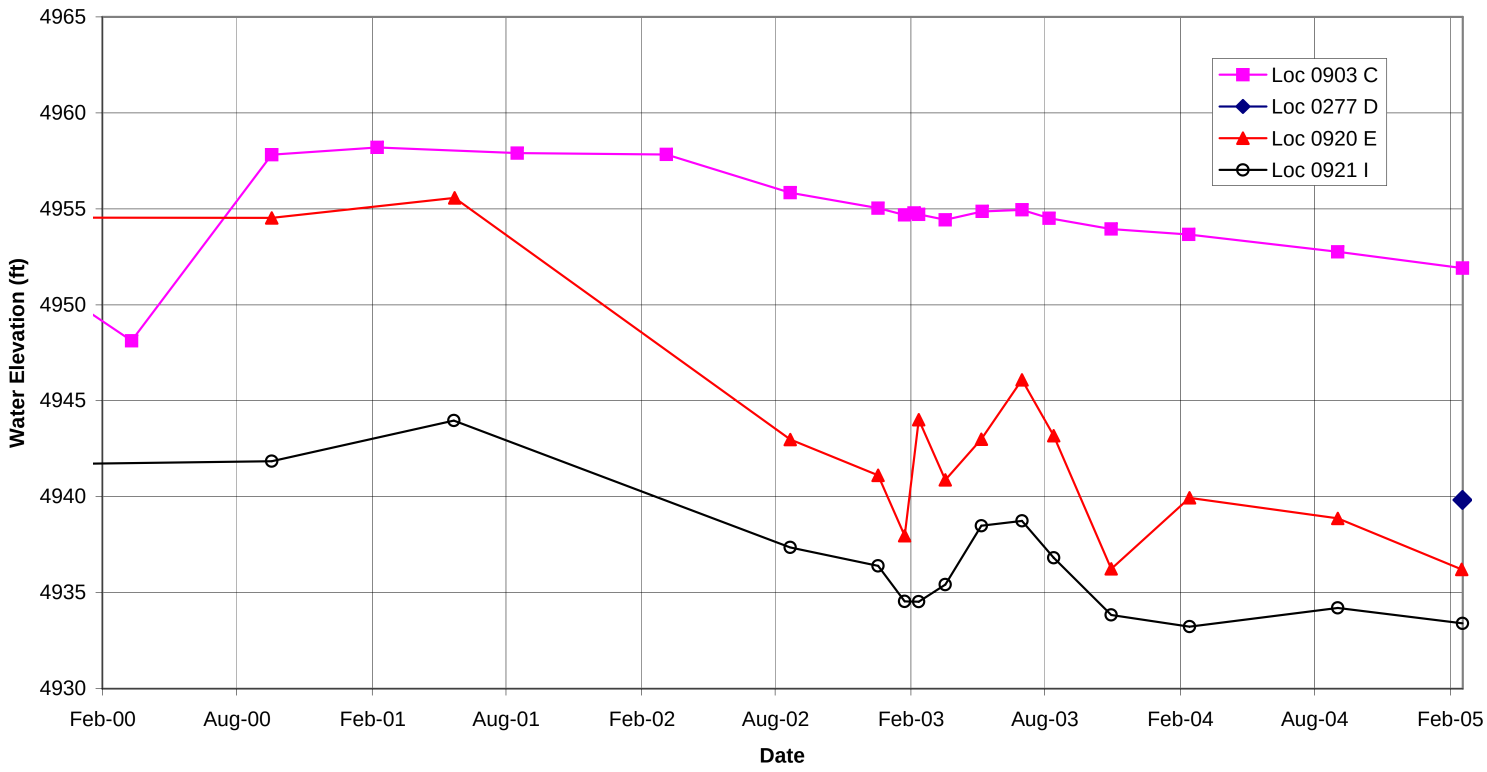

Figure C−12. Water Level Hydrographs: Lower Terrace Well Cluster

Appendix D

Contaminant Concentration Trends at Monitor Wells

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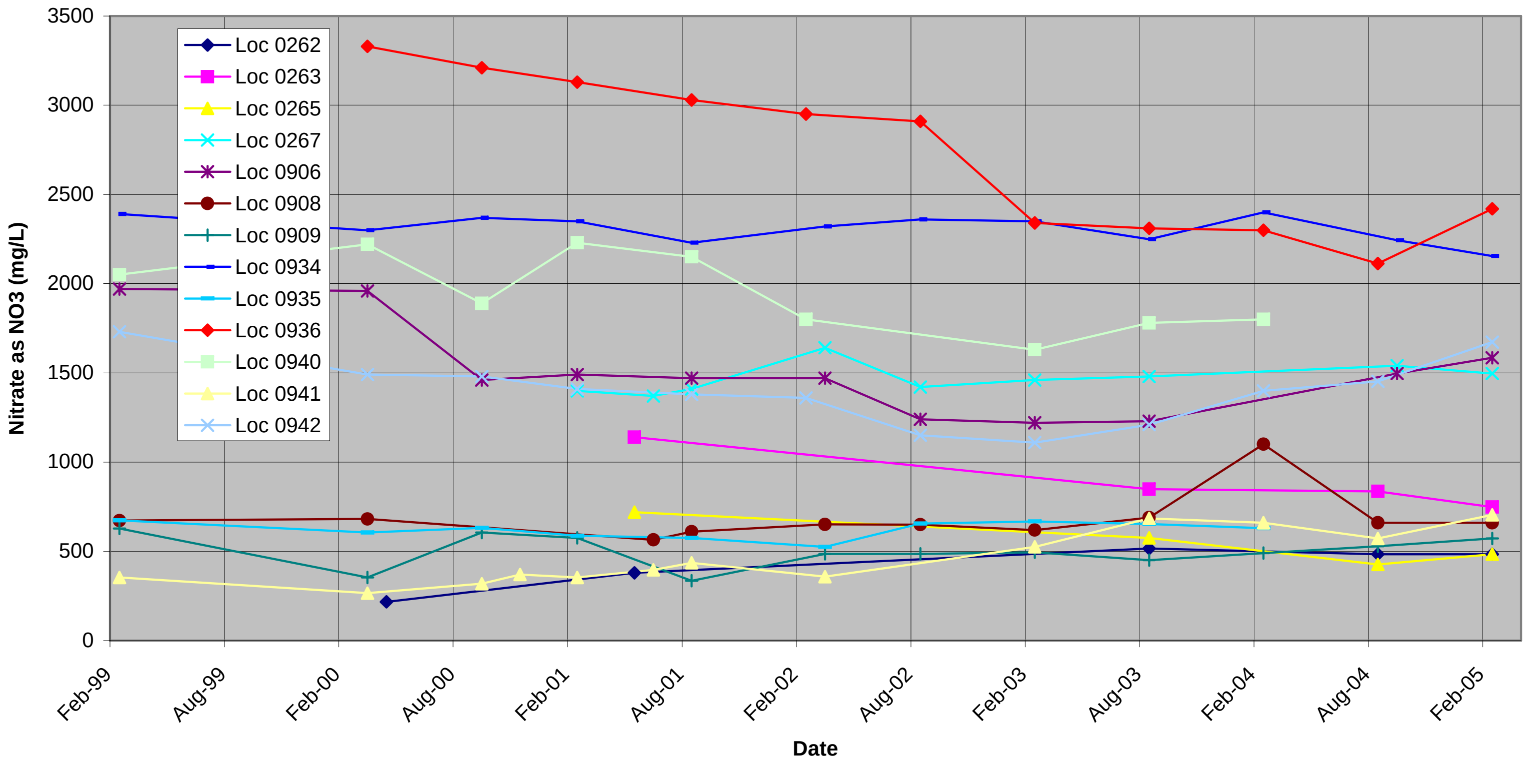
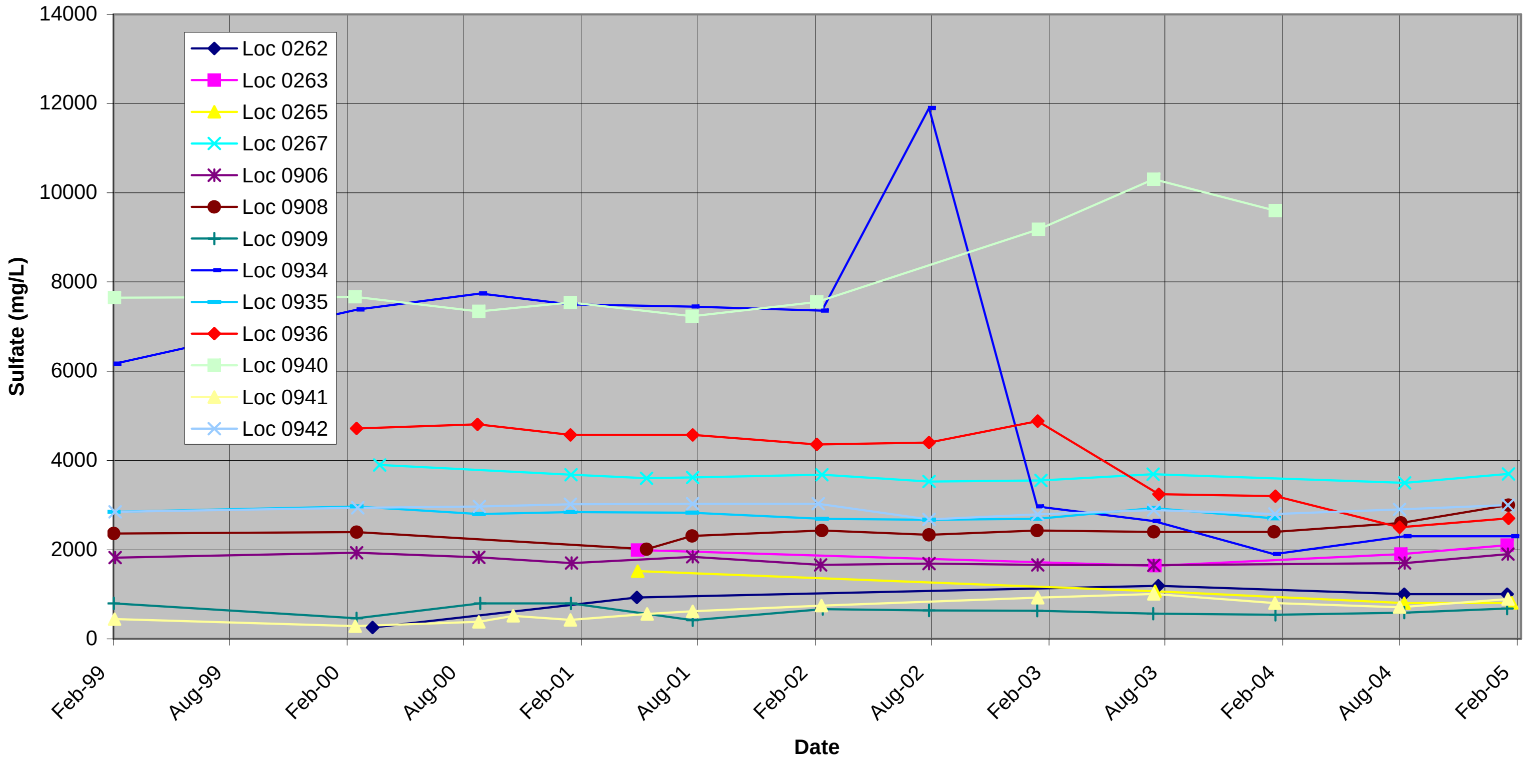
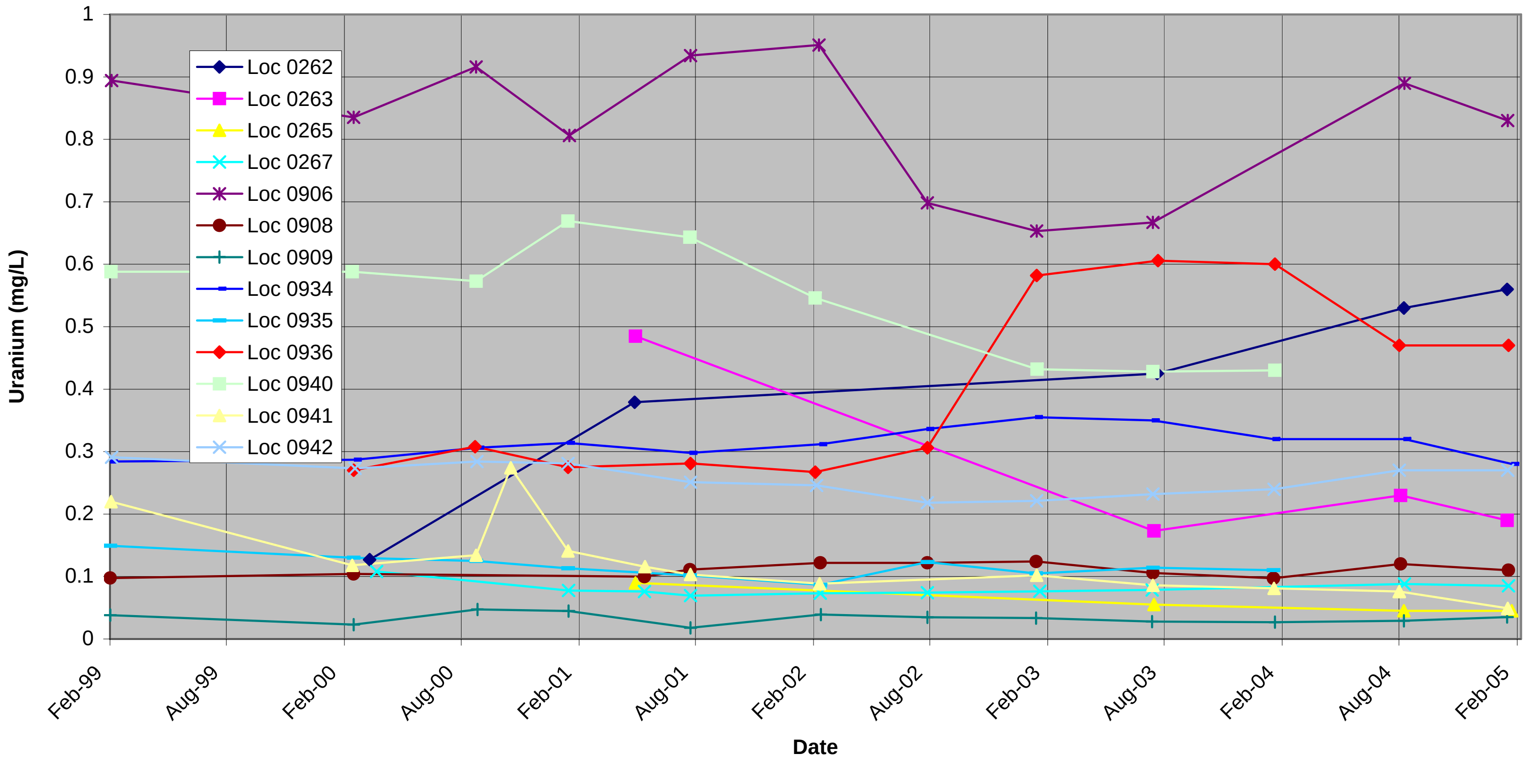


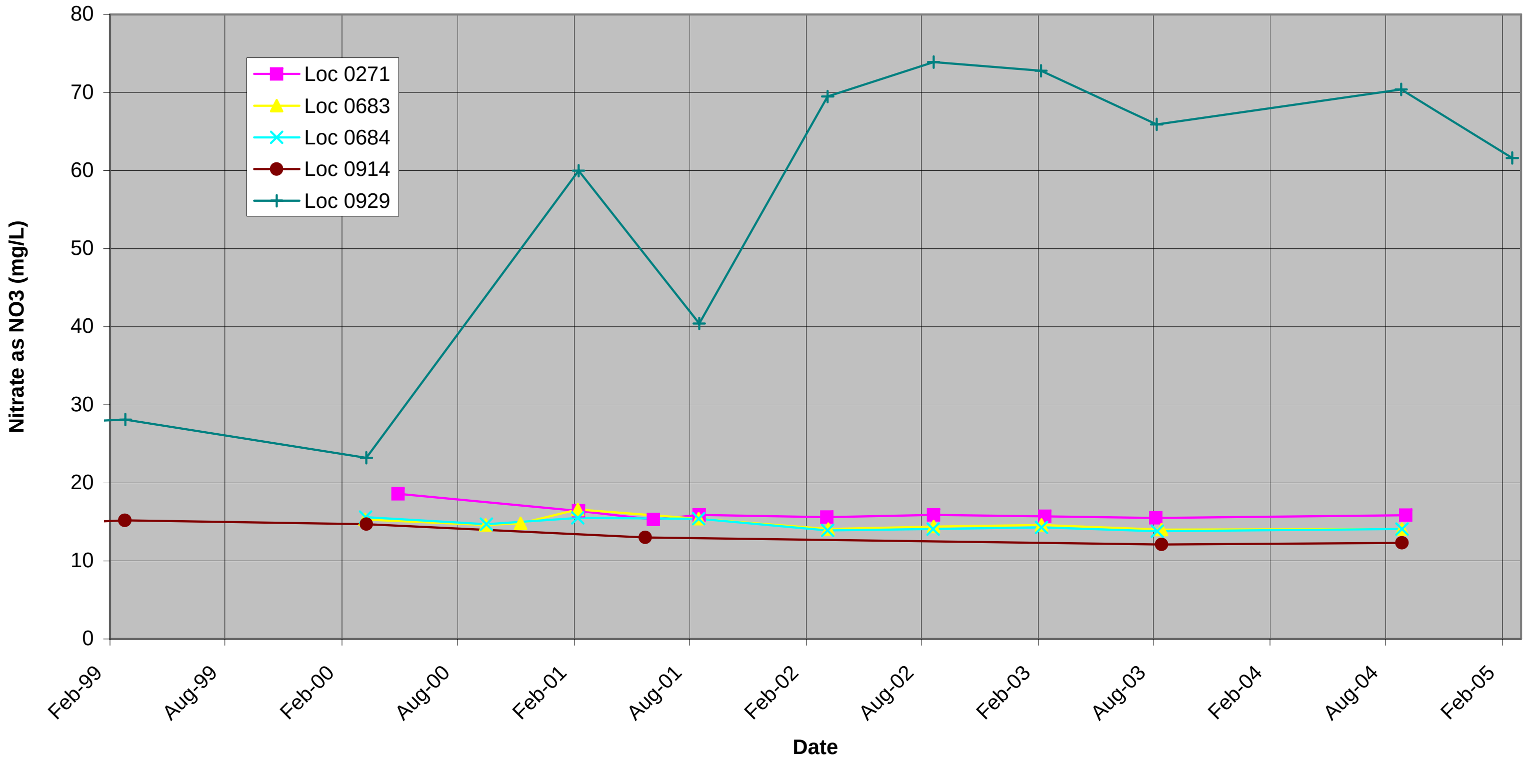
D−1. Horizons A and B Monitor Wells, Nitrate as NO_3 Concentration



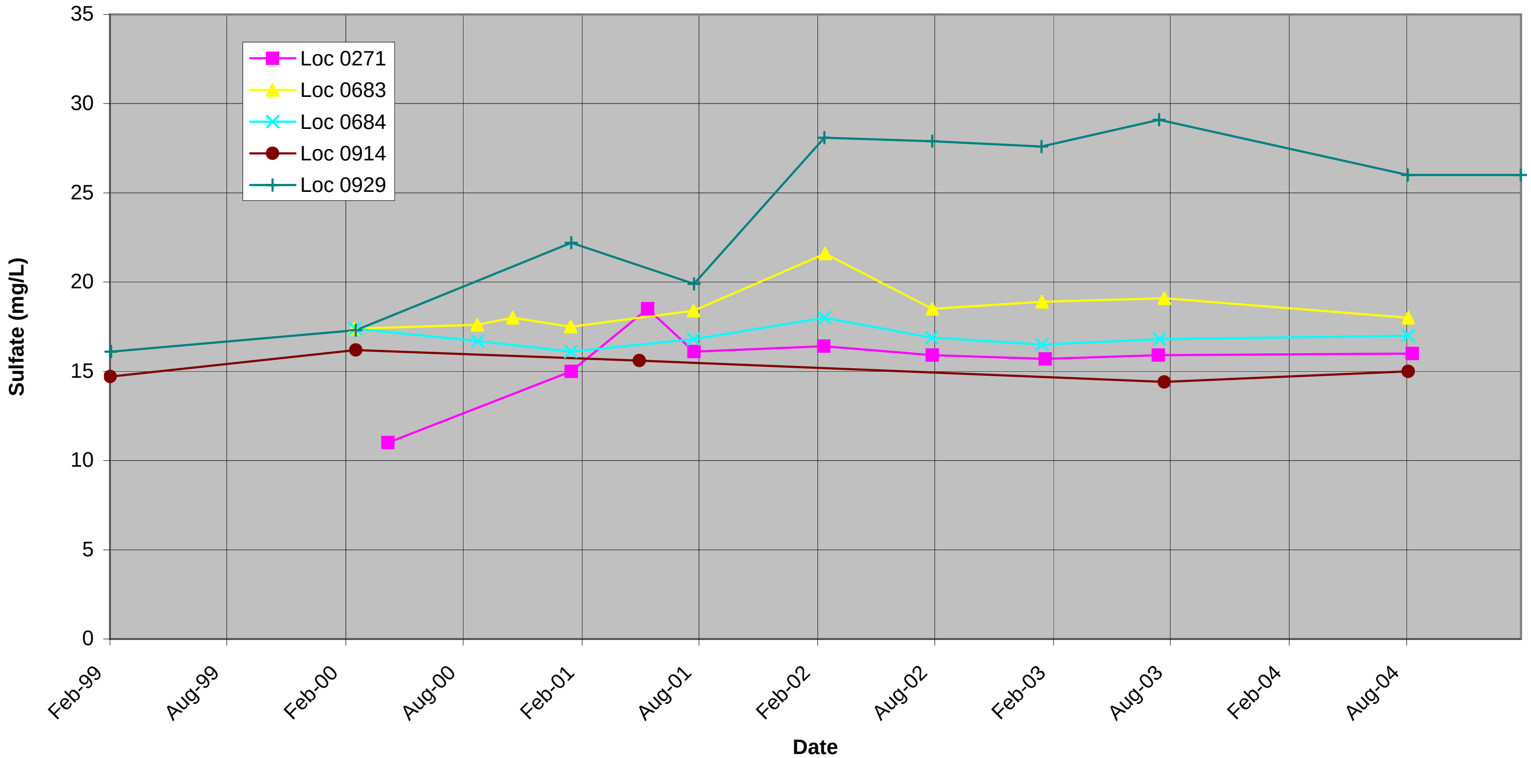
D−2. Horizons A and B Monitor Wells, Sulfate Concentration



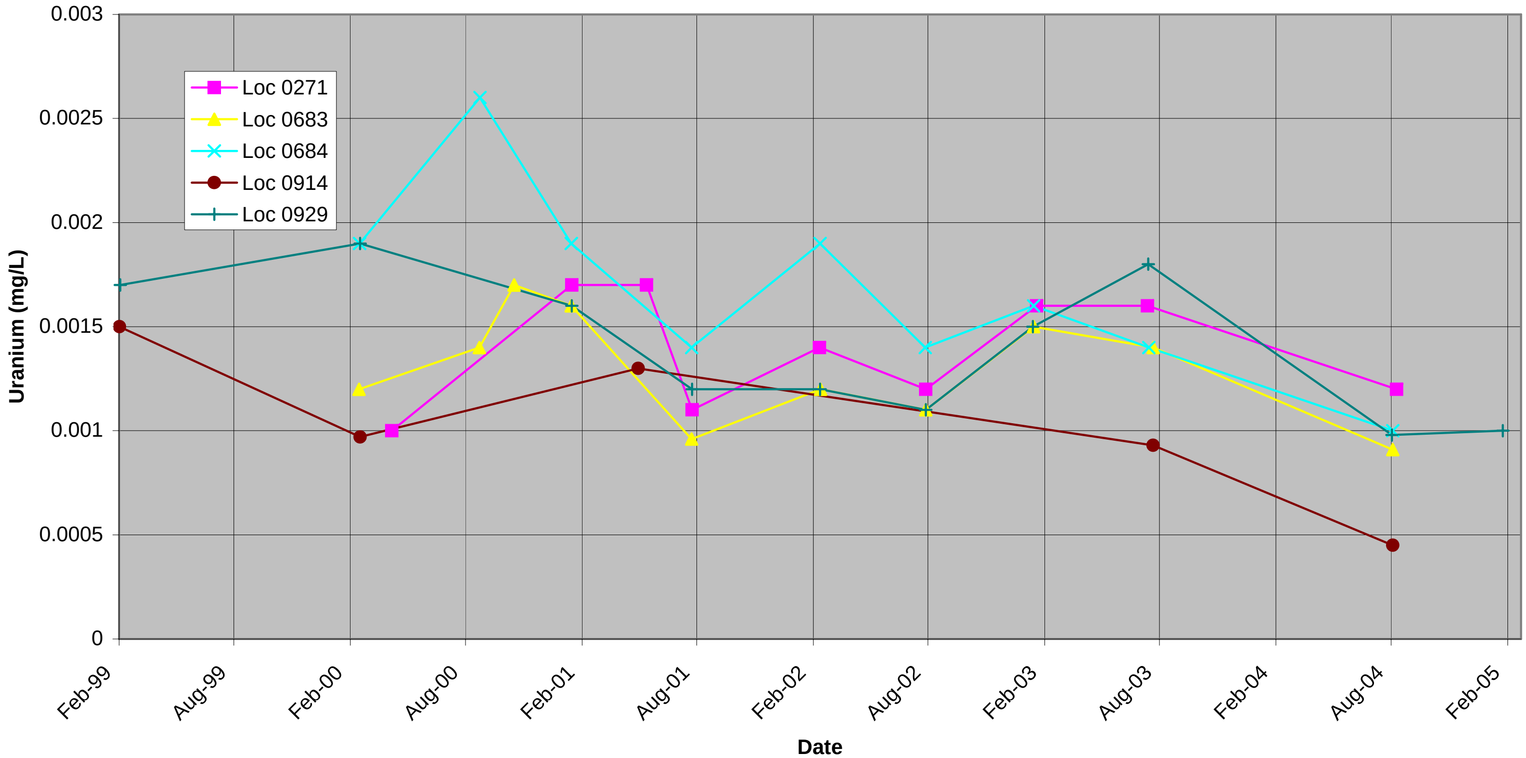
D−3. Horizons A and B Monitor Wells, Uranium Concentration



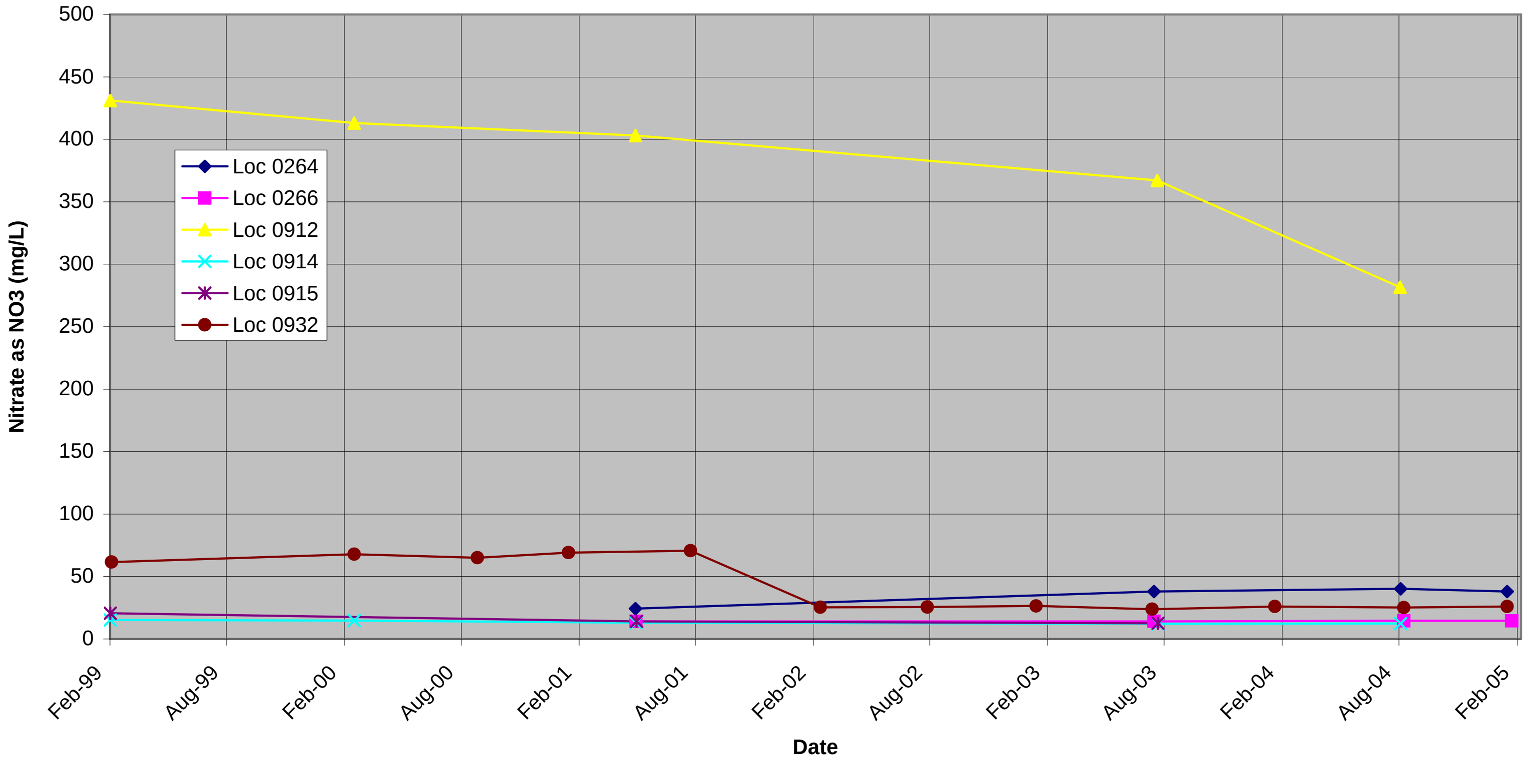
D−4. Horizons A and B Sentinel Wells, Nitrate as NO_3 Concentration



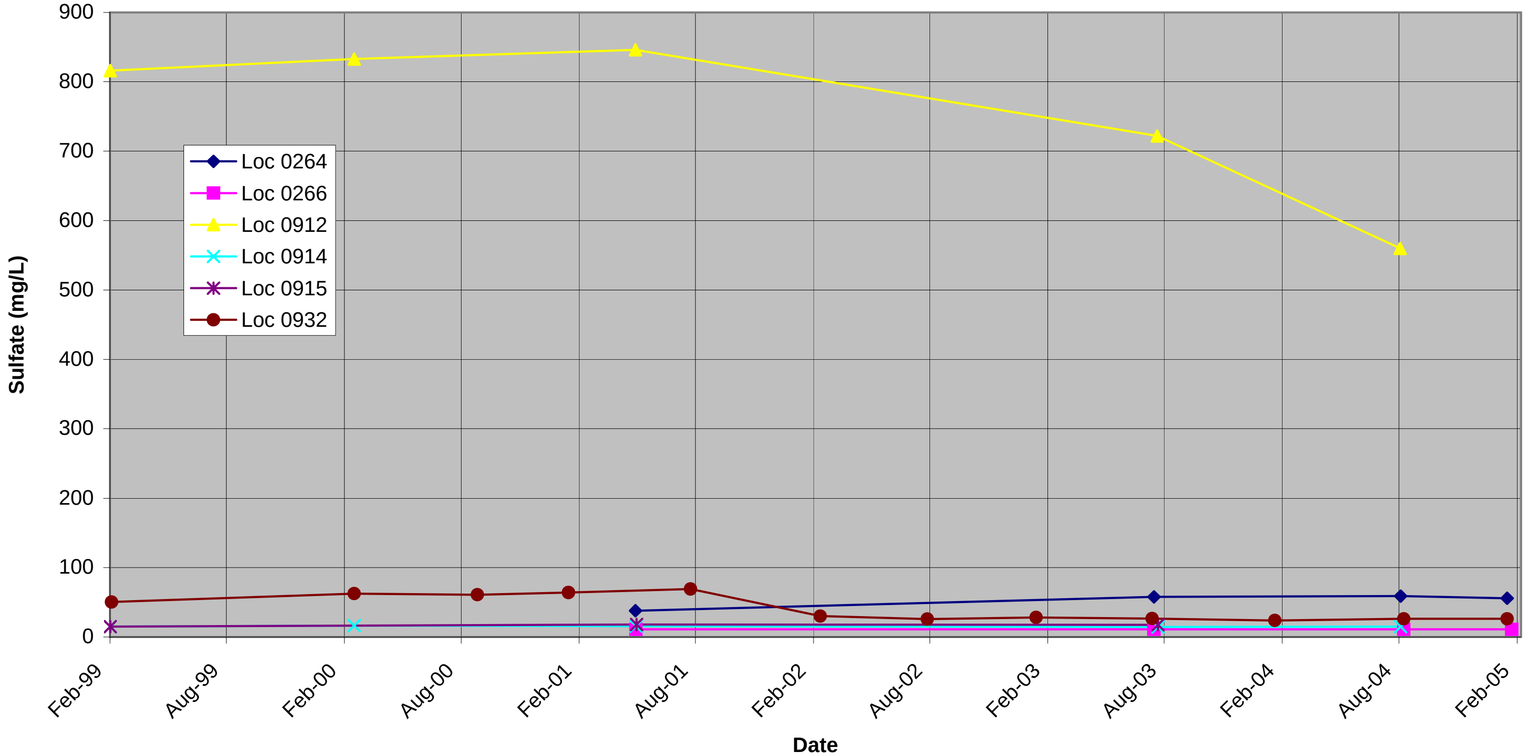
D−5. Horizons A and B Sentinel Wells, Sulfate Concentration



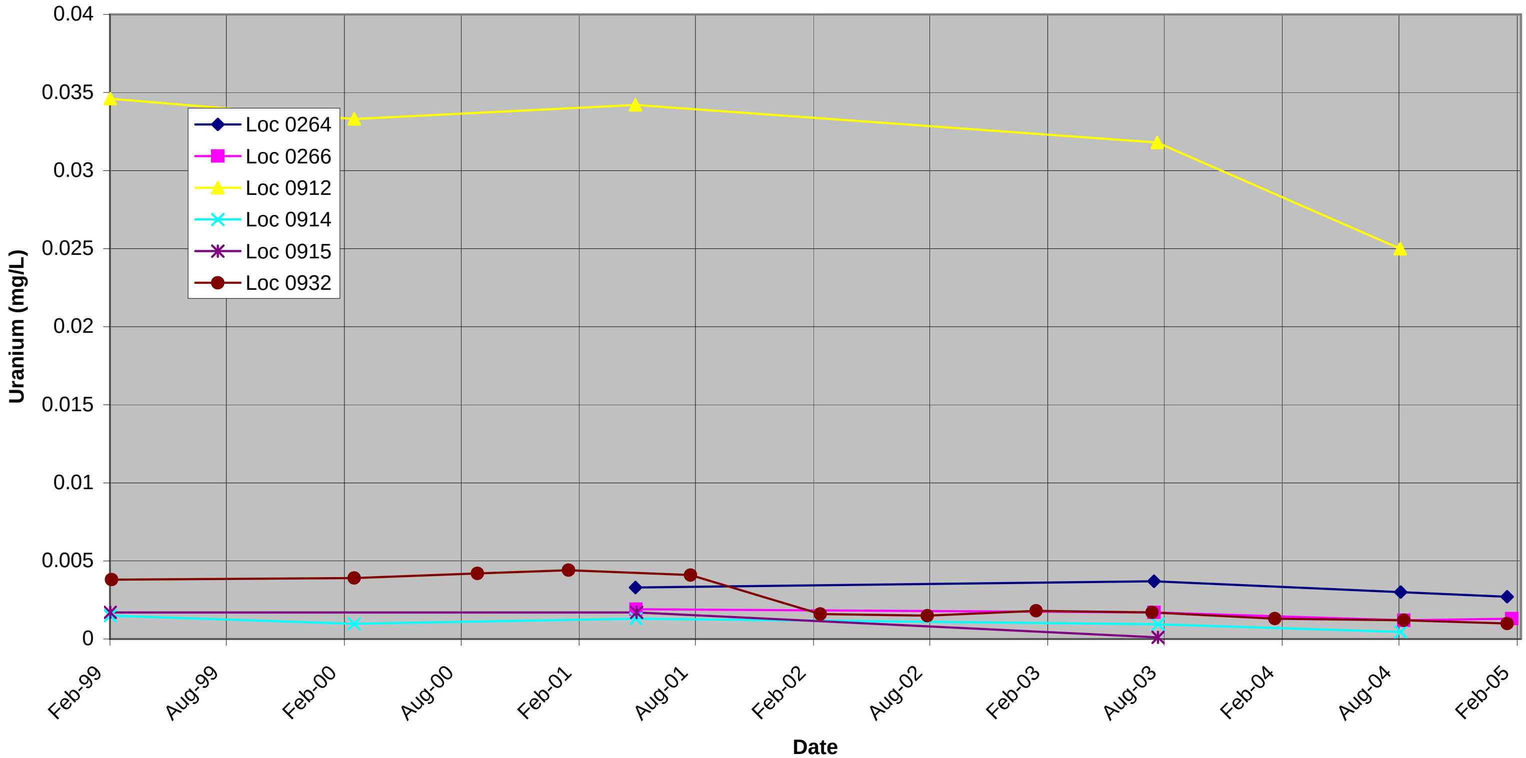
D–6. Horizons A and B Sentinel Wells, Uranium Concentration



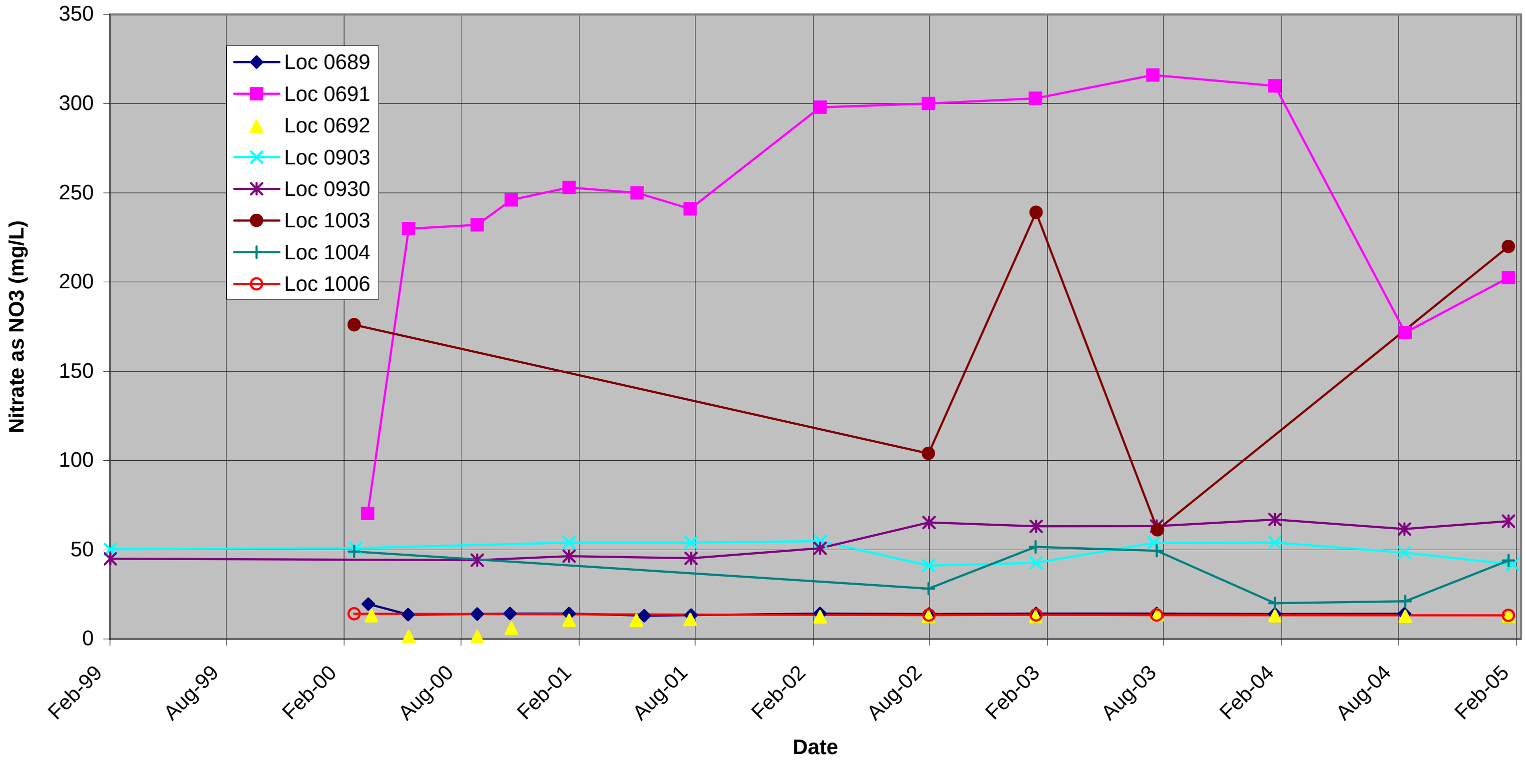
D−7. Horizons C and D Monitor Wells, Nitrate as NO_3 Concentration



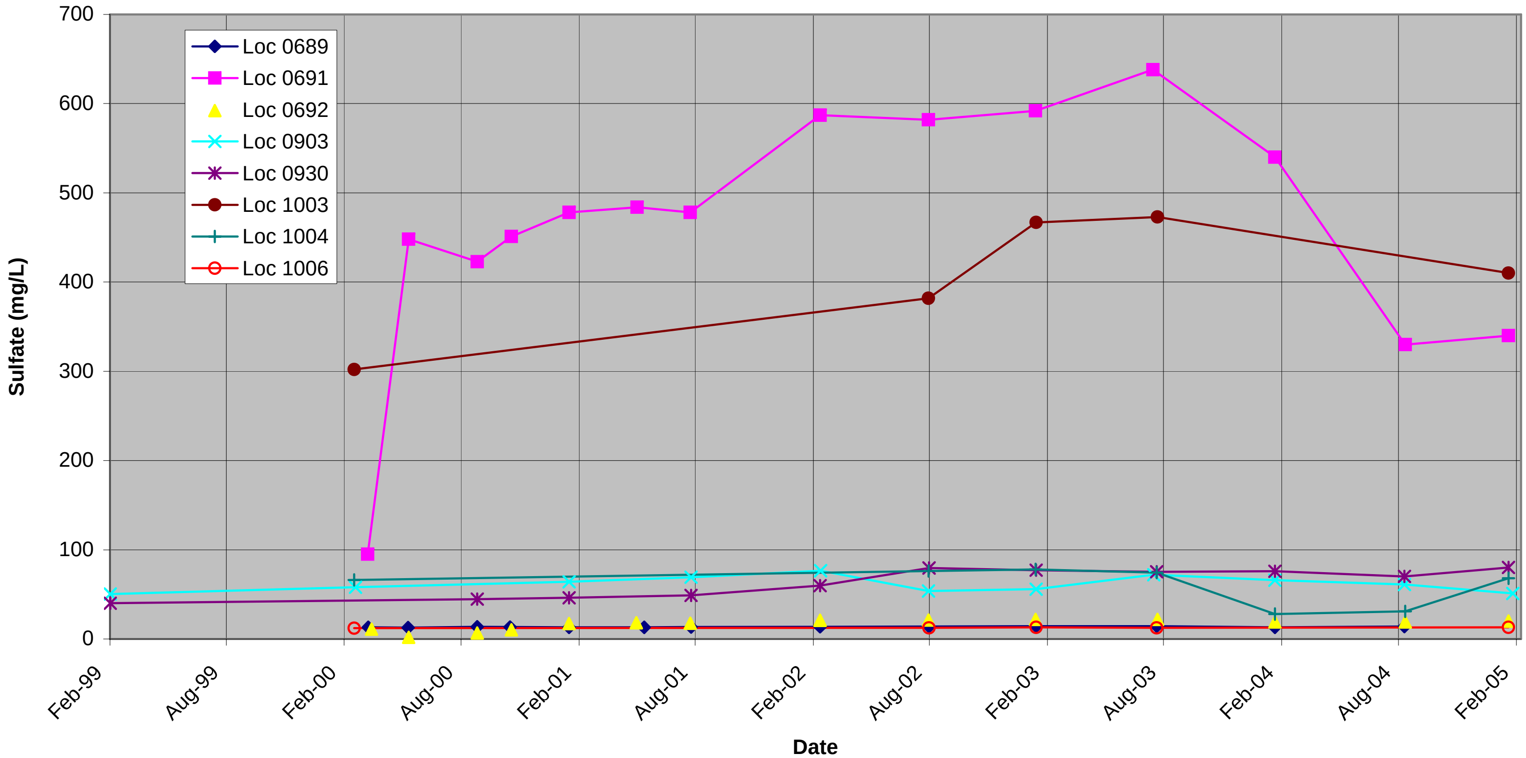
D−8. Horizons C and D Monitor Wells, Sulfate Concentration



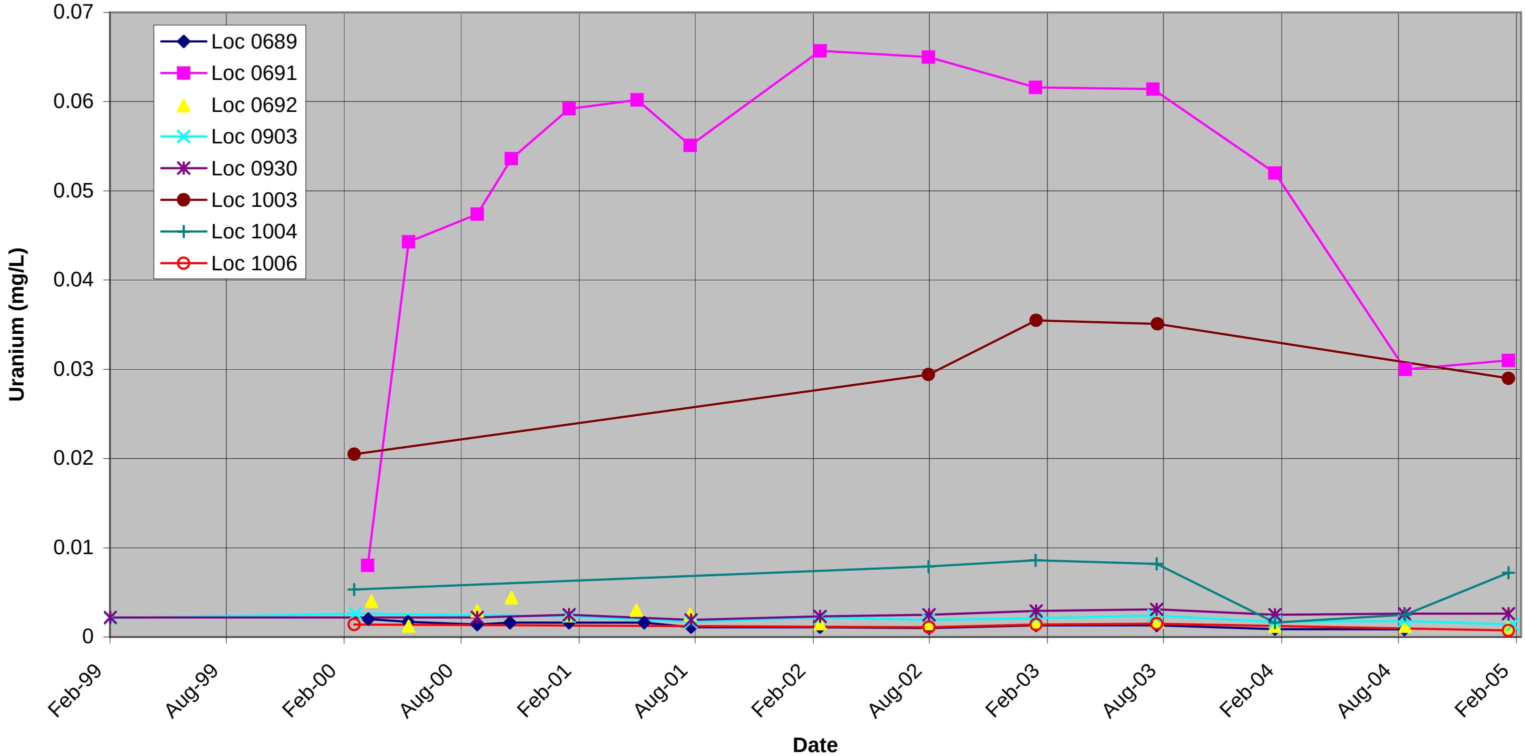
D−9. Horizons C and D Monitor Wells, Uranium Concentration



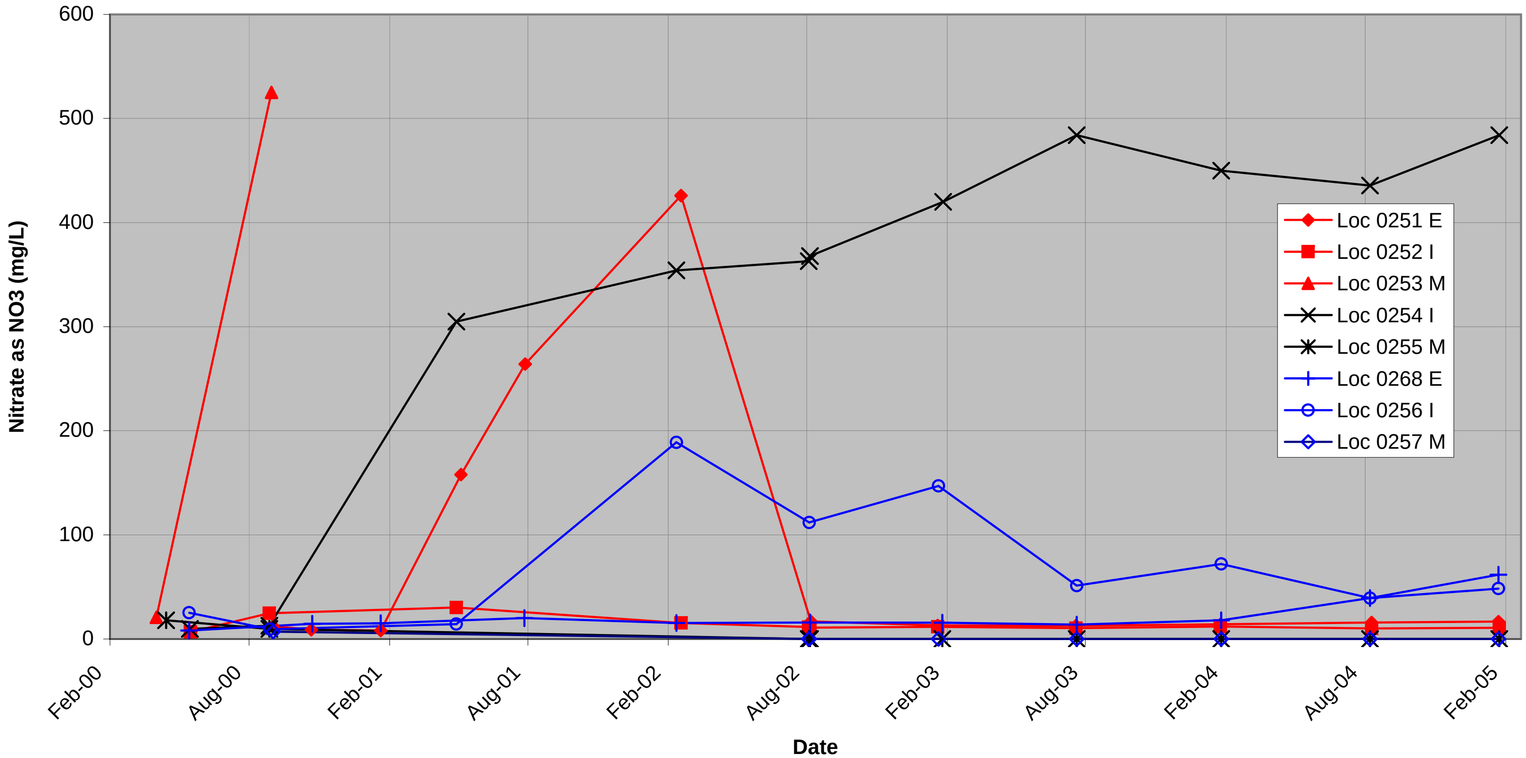
D−10. Lower Terrace Monitor Wells, Nitrate as NO_3 Concentration



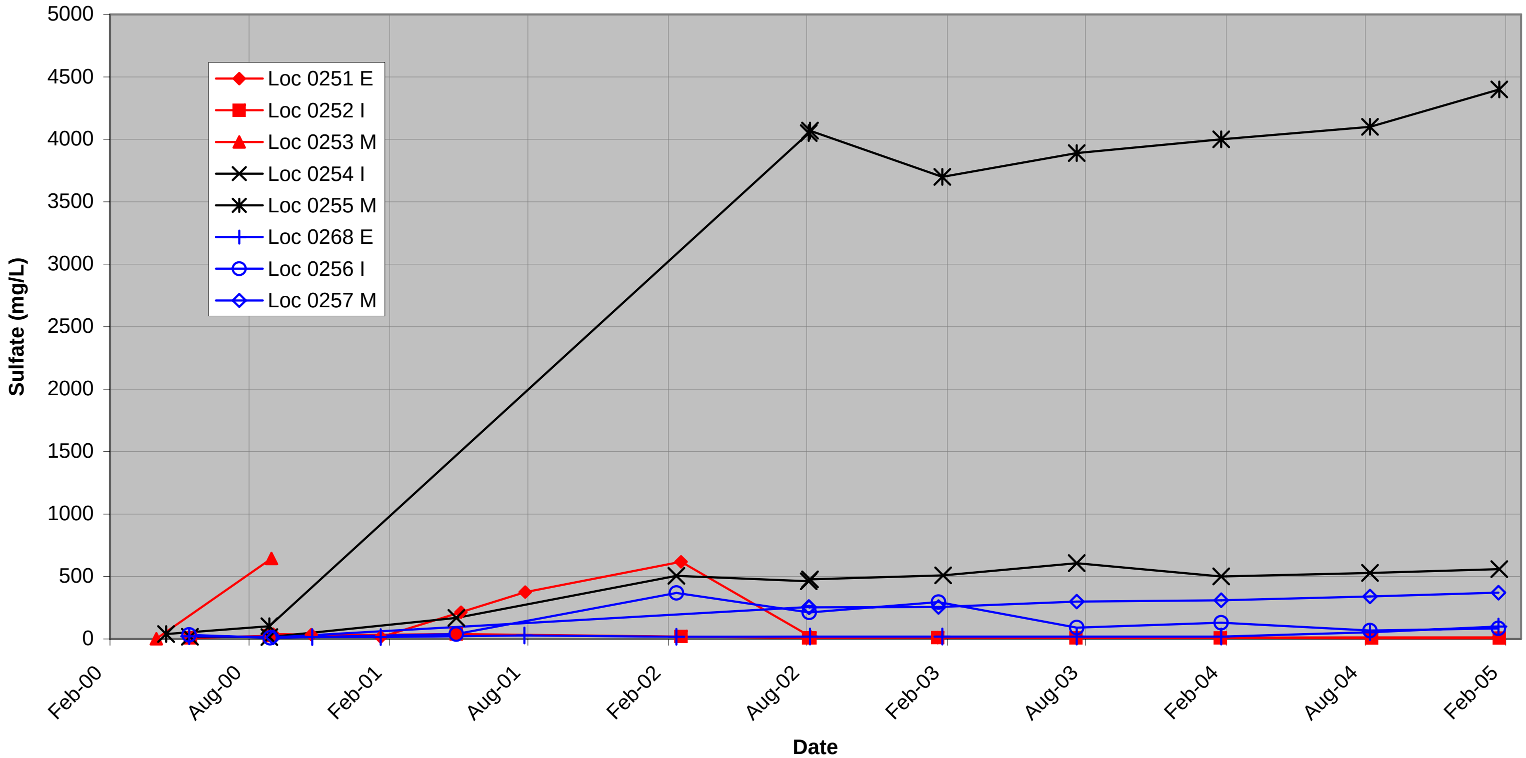
D−11. Lower Terrace Monitor Wells, Sulfate Concentration



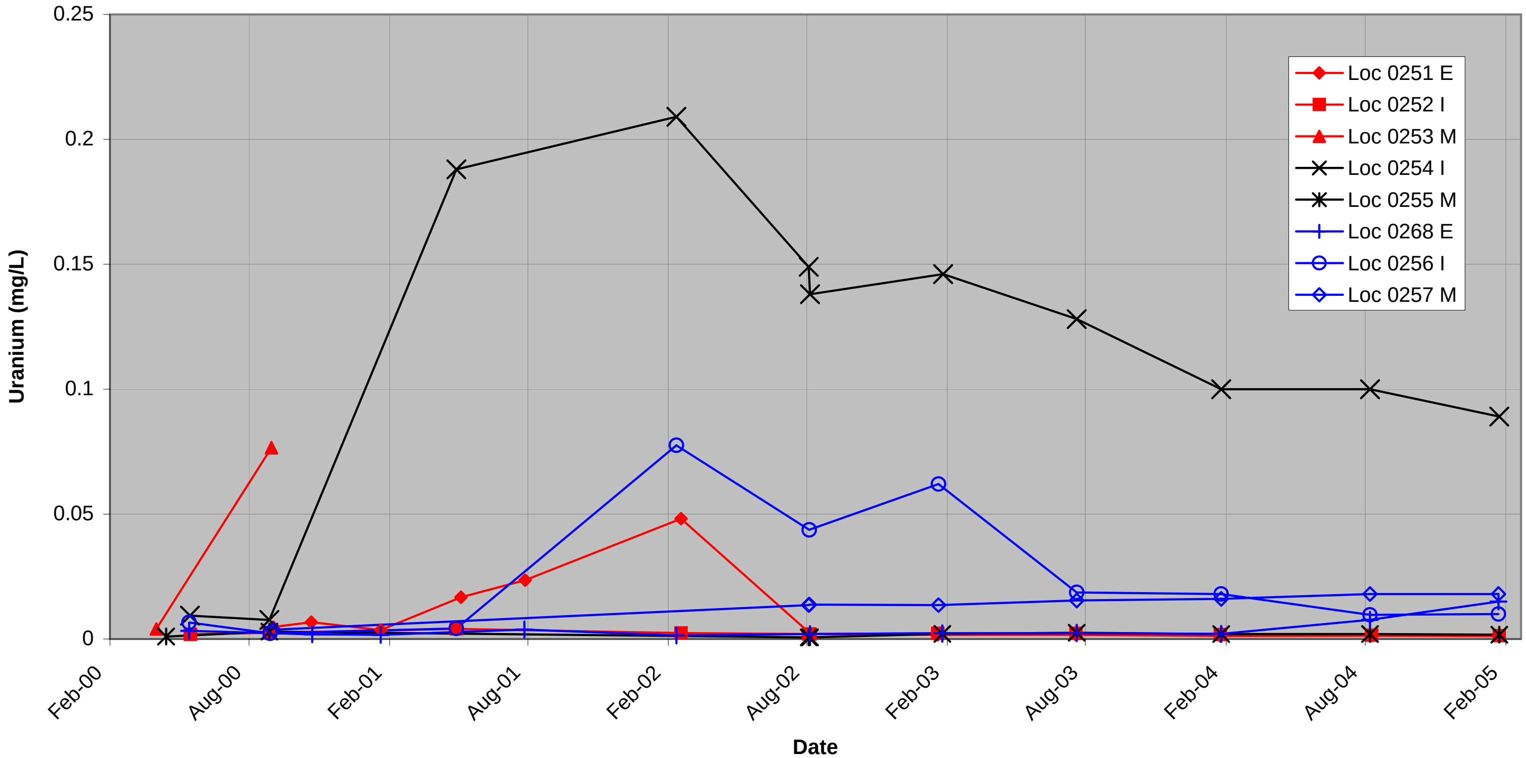
D−12. Lower Terrace Monitor Wells, Uranium Concentration



D−13. Deep Monitor Wells, Nitrate as NO_3 Concentration



D−14. Deep Monitor Wells, Sulfate Concentration



D–15. Deep Monitor Wells, Uranium Concentration

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Appendix E

Contaminant Concentrations at Extraction Wells

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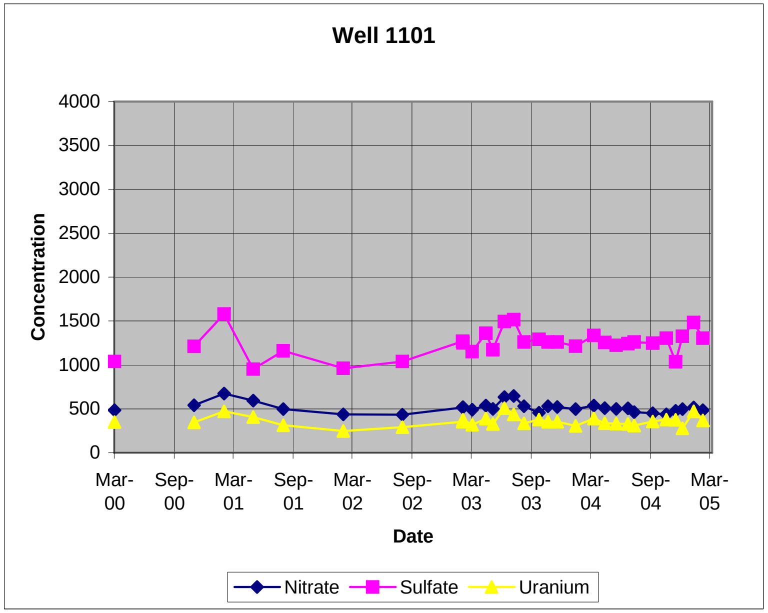
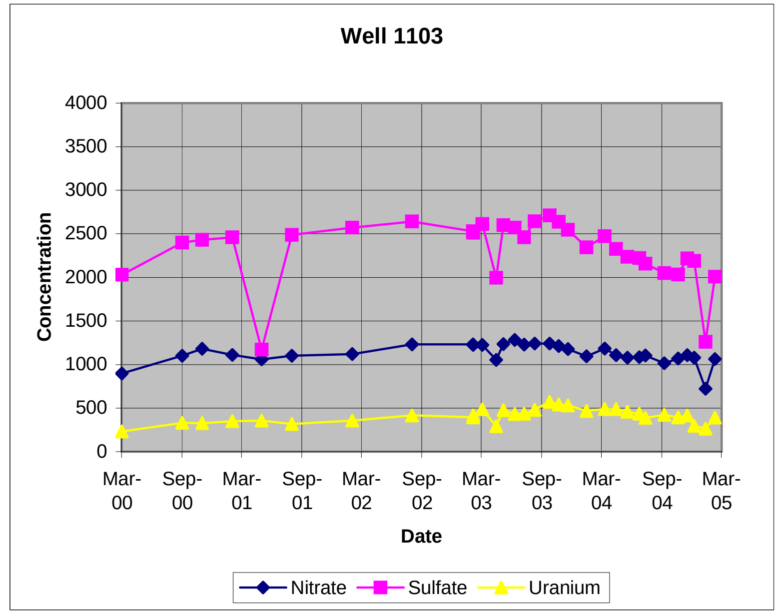
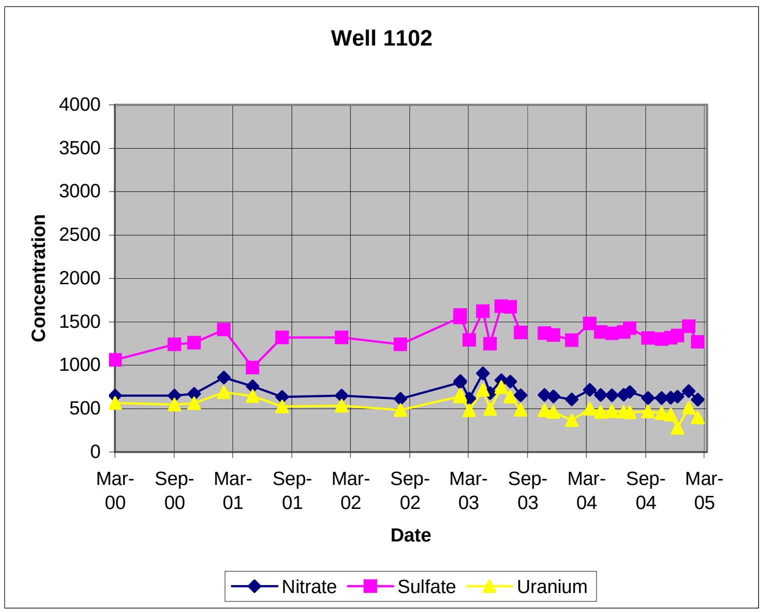
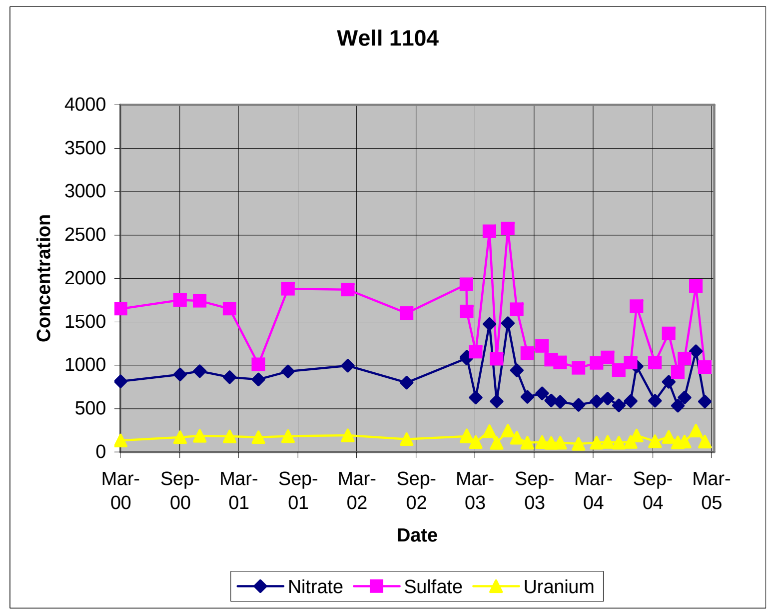
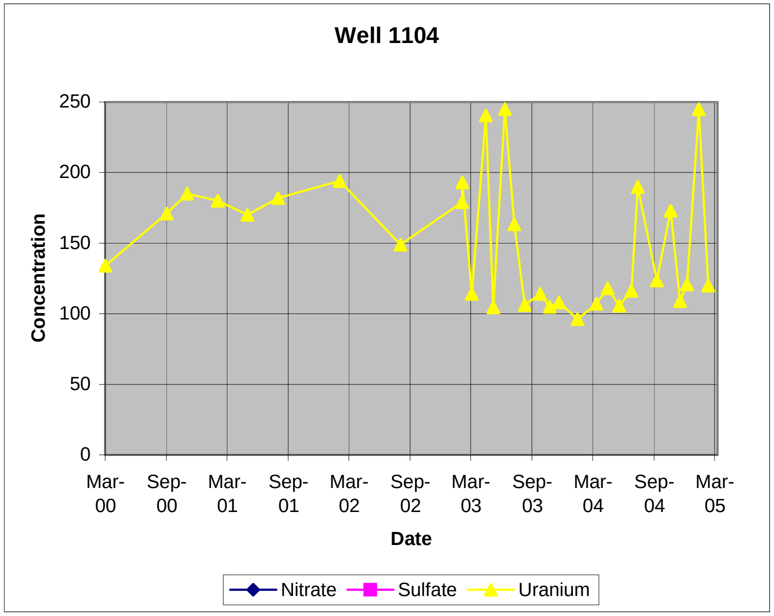
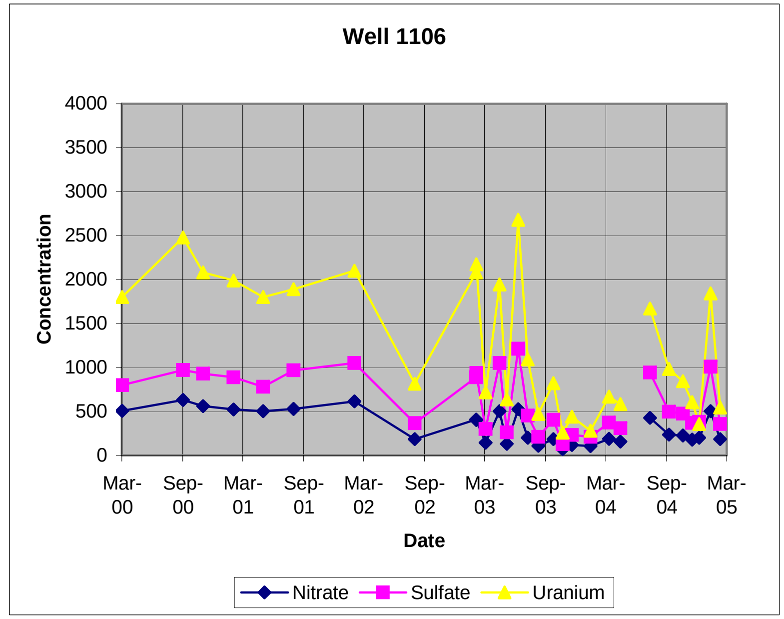

Well 1101
Concentration
4000
3500
3000
2500
2000
1500
1000
500
0
Mar-00
Sep-00
Mar-01
Sep-01
Mar-02
Sep-02
Mar-03
Sep-03
Mar-04
Sep-04
Mar-05
Date
Nitrate
Sulfate
Uranium


Well 1103
Concentration
4000
3500
3000
2500
2000
1500
1000
500
0
Mar-00
Sep-00
Mar-01
Sep-01
Mar-02
Sep-02
Mar-03
Sep-03
Mar-04
Sep-04
Mar-05
Date
Nitrate
Sulfate
Uranium


Well 1102
Concentration
4000
3500
3000
2500
2000
1500
1000
500
0
Mar-00
Sep-00
Mar-01
Sep-01
Mar-02
Sep-02
Mar-03
Sep-03
Mar-04
Sep-04
Mar-05
Date
Nitrate
Sulfate
Uranium


Well 1104
Concentration
4000
3500
3000
2500
2000
1500
1000
500
0
Mar-00
Sep-00
Mar-01
Sep-01
Mar-02
Sep-02
Mar-03
Sep-03
Mar-04
Sep-04
Mar-05
Date
Nitrate
Sulfate
Uranium


Well 1104
Concentration
250
200
150
100
50
0
Mar-00
Sep-00
Mar-01
Sep-01
Mar-02
Sep-02
Mar-03
Sep-03
Mar-04
Sep-04
Mar-05
Date
Nitrate
Sulfate
Uranium


Well 1106
Concentration
4000
3500
3000
2500
2000
1500
1000
500
0
Mar-00
Sep-00
Mar-01
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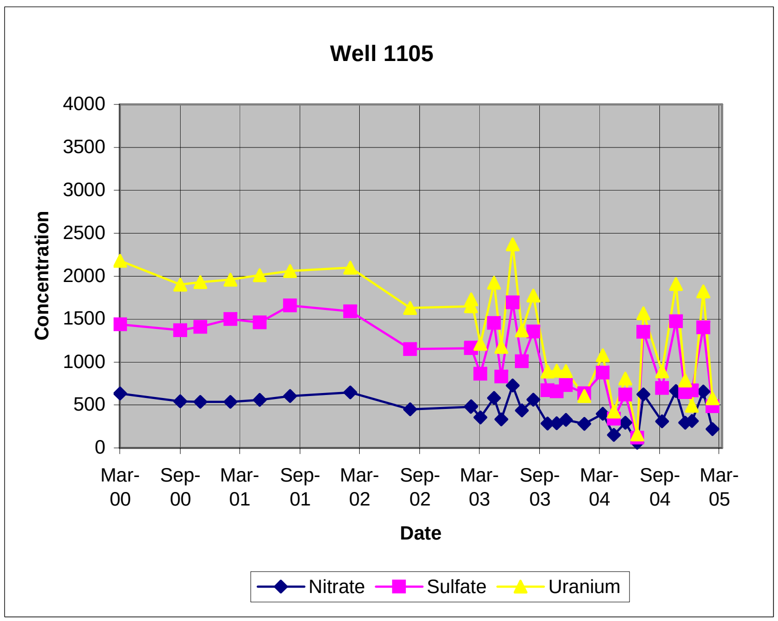
Sep-02
Mar-03
Sep-03
Mar-04
Sep-04
Mar-05
Date
Nitrate
Sulfate
Uranium


Well 1105
Concentration
4000
3500
3000
2500
2000
1500
1000
500
0
Mar-00
Sep-00
Mar-01
Sep-01
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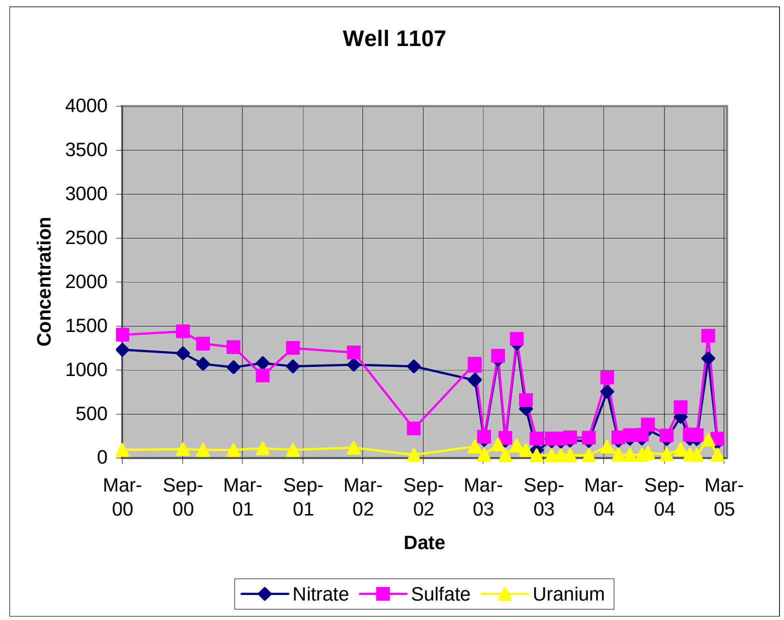
Sep-02
Mar-03
Sep-03
Mar-04
Sep-04
Mar-05
Date
Nitrate
Sulfate
Uranium


Well 1107
Concentration
4000
3500
3000
2500
2000
1500
1000
500
0
Mar-00
Sep-00
Mar-01
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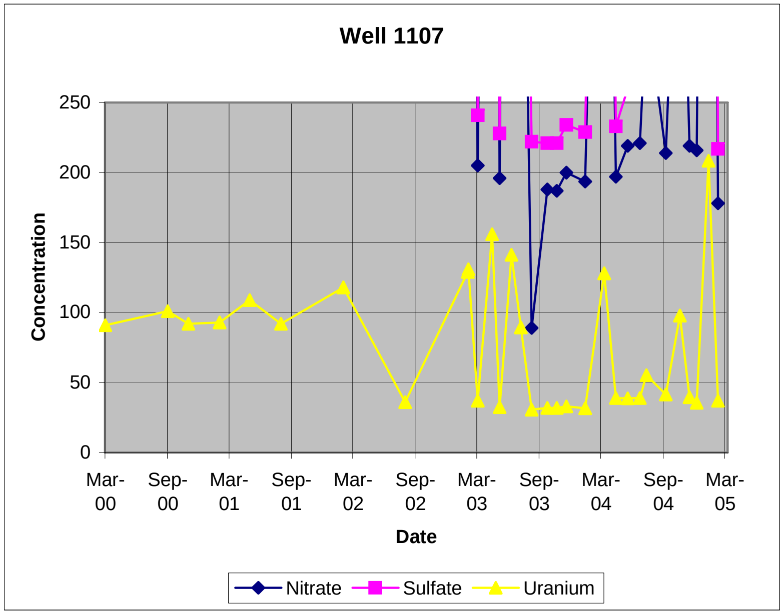
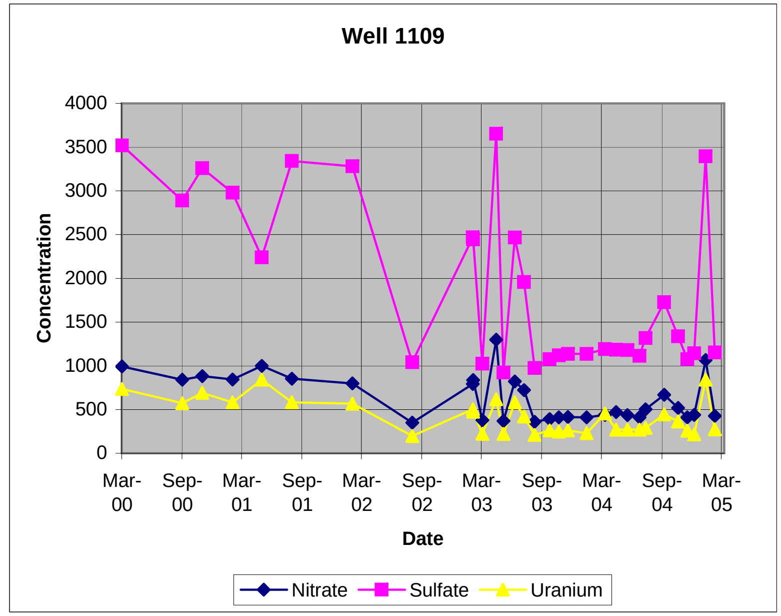
Mar-03
Sep-03
Mar-04
Sep-04
Mar-05
Date
Nitrate
Sulfate
Uranium


Well 1107
250
200
150
100
50
0
Concentration
Mar-00
Sep-00
Mar-01
Sep-01
Mar-02
Sep-02
Mar-03
Sep-03
Mar-04
Sep-04
Mar-05
Date
Nitrate
Sulfate
Uranium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3000
2500
2000
1500
1000
500
0
Concentration
Mar-00
Sep-00
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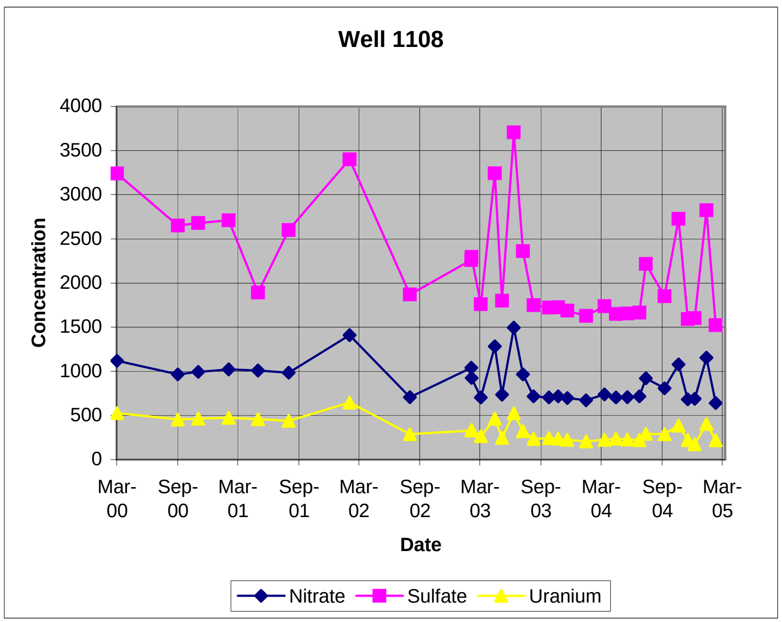
Sep-02
Mar-03
Sep-03
Mar-04
Sep-04
Mar-05
Date
Nitrate
Sulfate
Uranium


Well 1108
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3500
3000
2500
2000
1500
1000
500
0
Concentration
Mar-00
Sep-00
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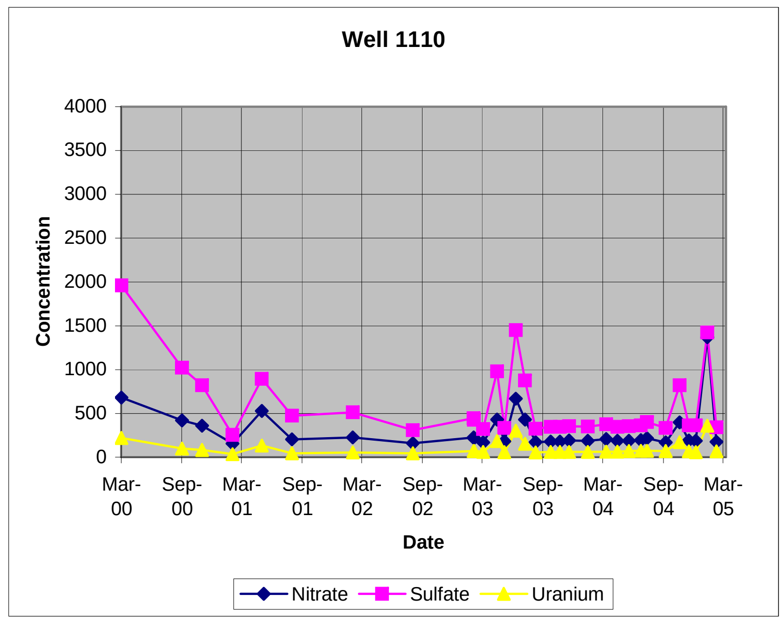
Sep-02
Mar-03
Sep-03
Mar-04
Sep-04
Mar-05
Date
Nitrate
Sulfate
Uranium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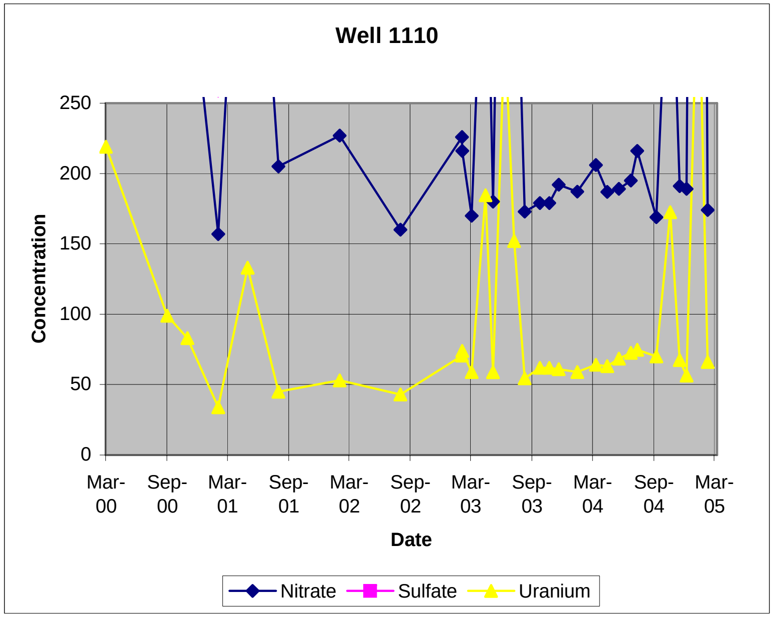
3500
3000
2500
2000
1500
1000
500
0
Concentration
Mar-00
Sep-00
Mar-01
Sep-01
Mar-02
Sep-02
Mar-03
Sep-03
Mar-04
Sep-04
Mar-05
Date
Nitrate
Sulfate
Uranium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Concentration
250
200
150
100
50
0
Mar-00
Sep-00
Mar-01
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Sep-02
Mar-03
Sep-03
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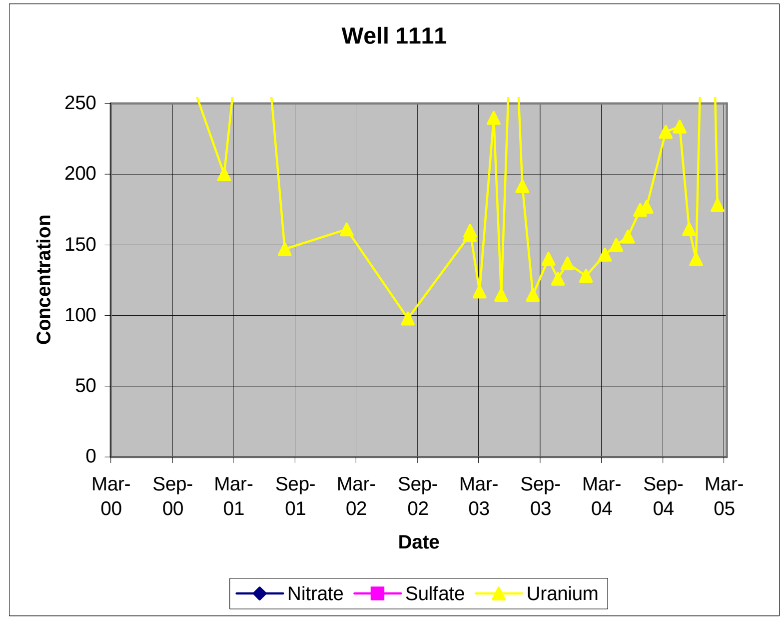
Sep-04
Mar-05
Date
Nitrate
Sulfate
Uranium


Well 1111
Concentration
250
200
150
100
50
0
Mar-00
Sep-00
Mar-01
Sep-01
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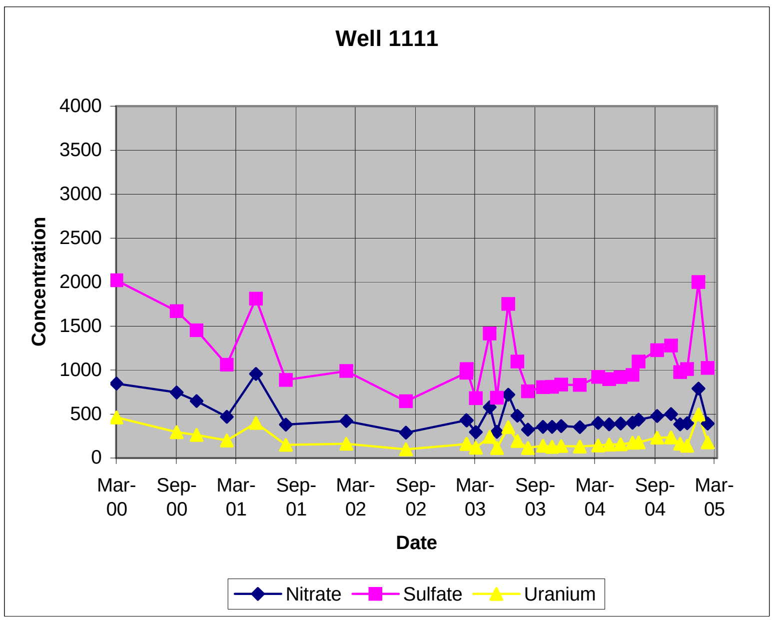
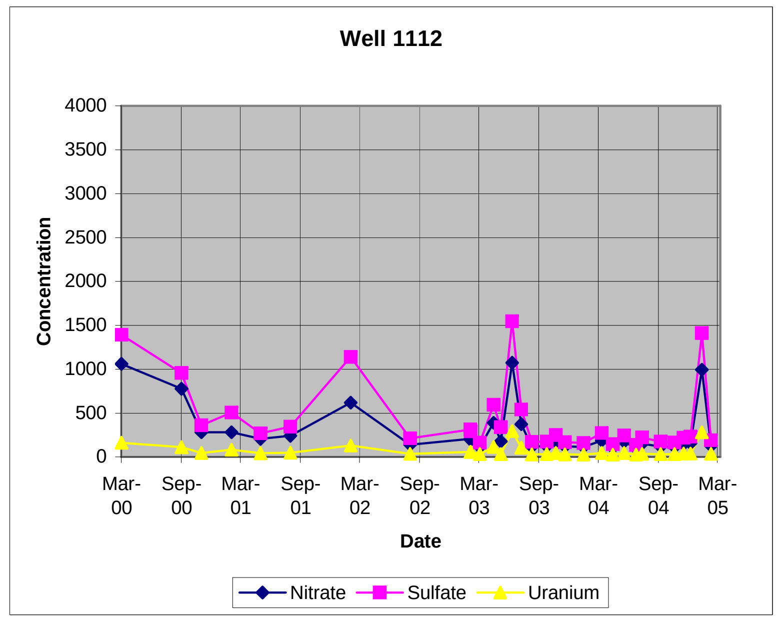
Sep-02
Mar-03
Sep-03
Mar-04
Sep-04
Mar-05
Date
Nitrate
Sulfate
Uranium


Well 1111
Concentration
4000
3500
3000
2500
2000
1500
1000
500
0
Mar-00
Sep-00
Mar-01
Sep-01
Mar-02
Sep-02
Mar-03
Sep-03
Mar-04
Sep-04
Mar-05
Date
Nitrate
Sulfate
Uranium


Well 1112
Concentration
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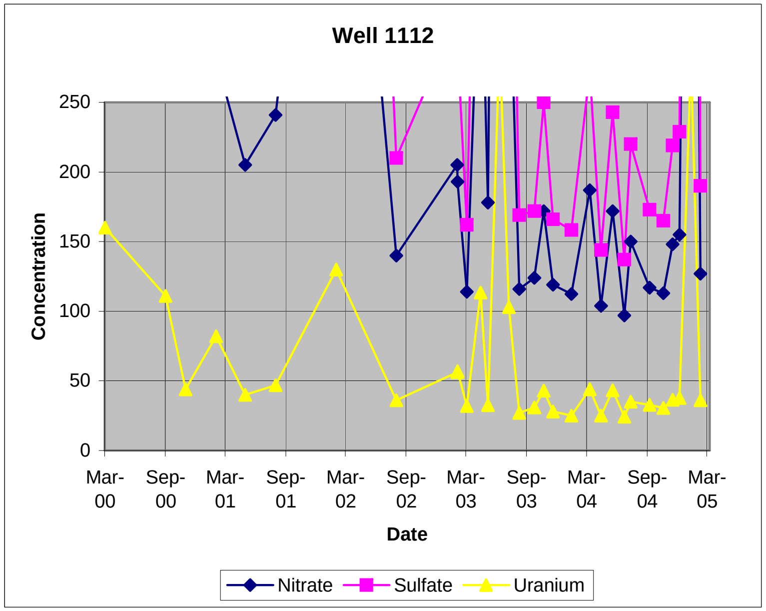
3500
3000
2500
2000
1500
1000
500
0
Mar-00
Sep-00
Mar-01
Sep-01
Mar-02
Sep-02
Mar-03
Sep-03
Mar-04
Sep-04
Mar-05
Date
Nitrate
Sulfate
Uranium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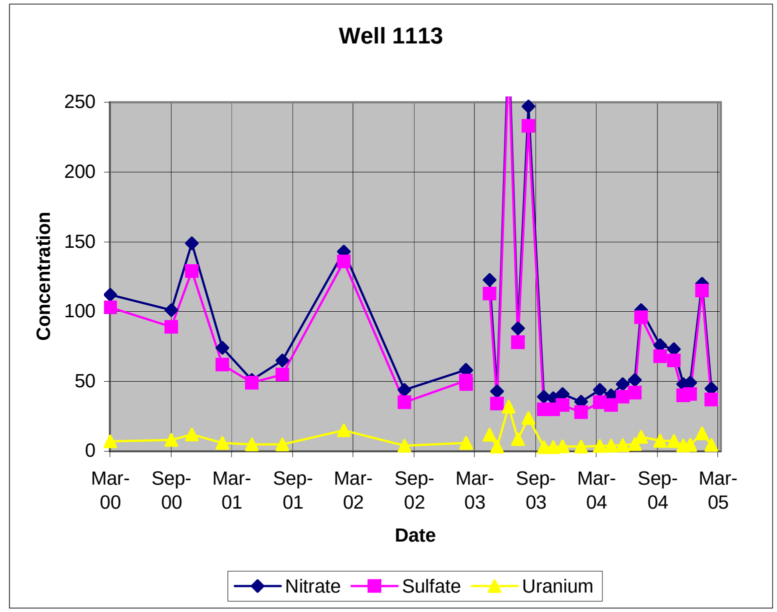
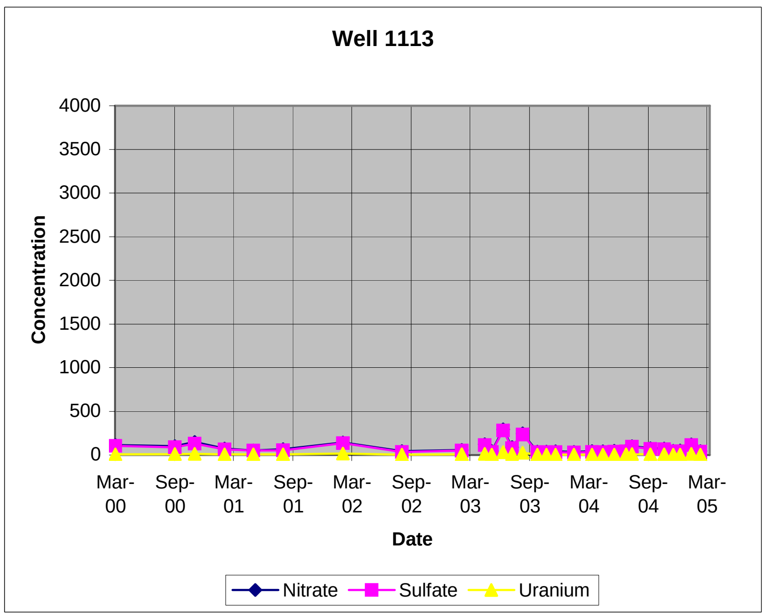
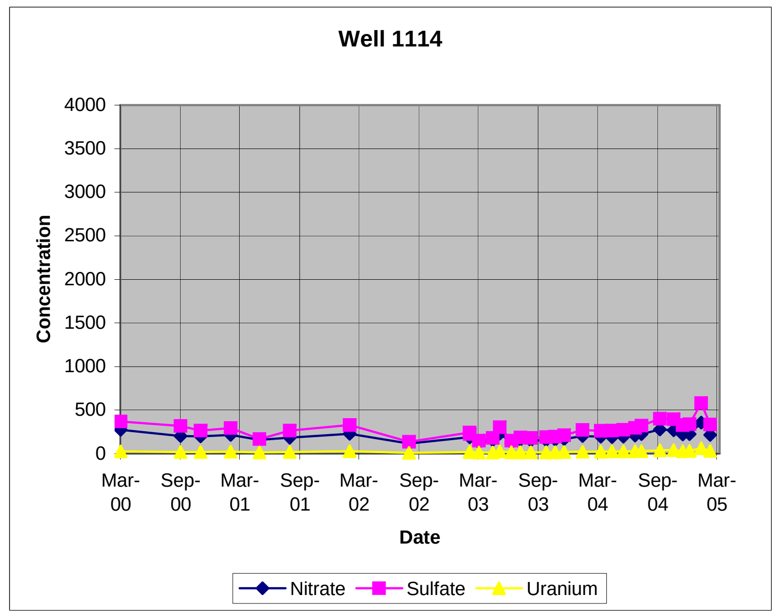
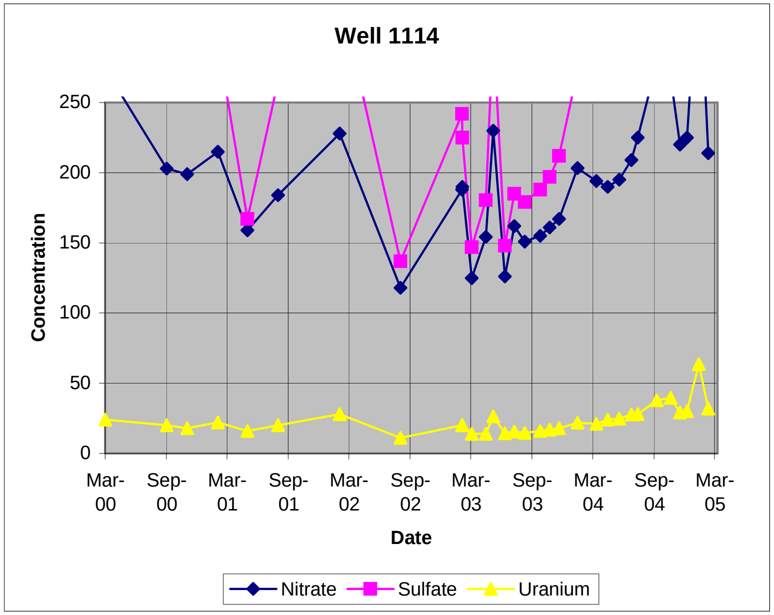
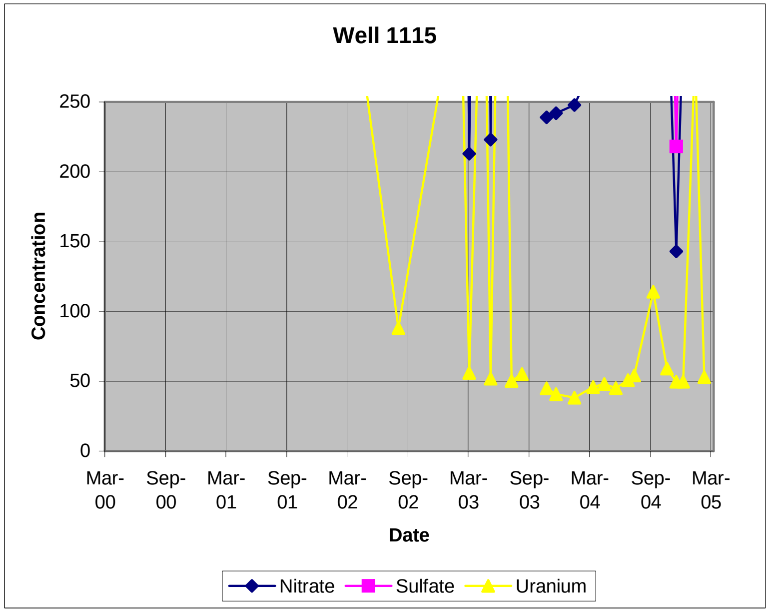
Concentration
250
200
150
100
50
0
Mar-00
Sep-00
Mar-01
Sep-01
Mar-02
Sep-02
Mar-03
Sep-03
Mar-04
Sep-04
Mar-05
Date
Nitrate
Sulfate
Uranium

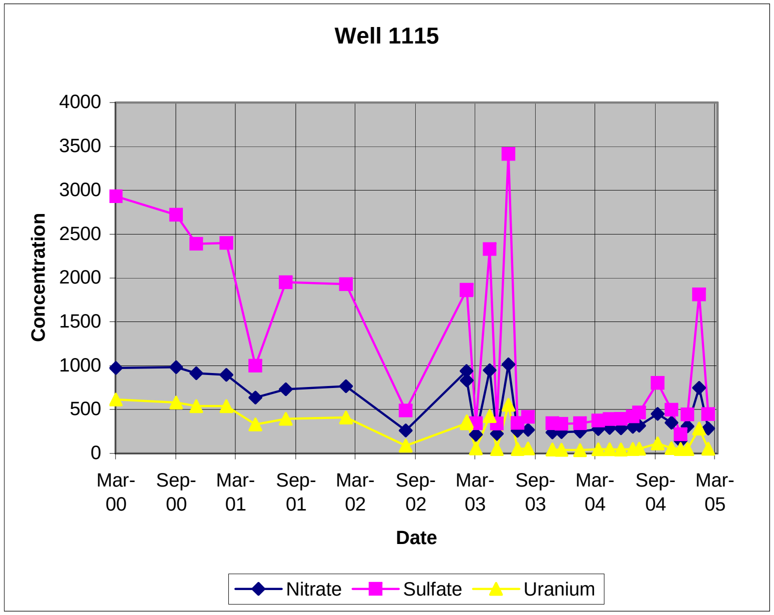

Well 1113
Concentration
250
200
150
100
50
0
Mar-00
Sep-00
Mar-01
Sep-01
Mar-02
Sep-02
Mar-03
Sep-03
Mar-04
Sep-04
Mar-05
Date
Nitrate
Sulfate
Uranium

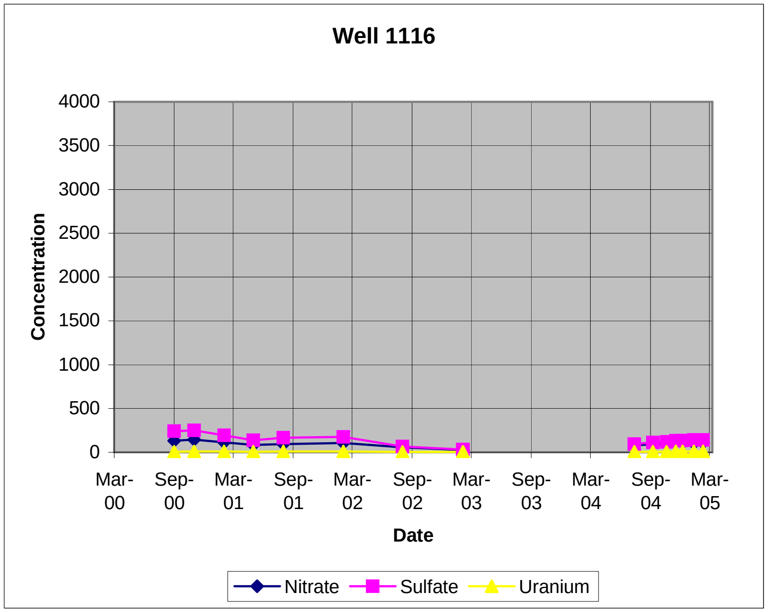

Well 1113
Concentration
4000
3500
3000
2500
2000
1500
1000
500
0
Mar-00
Sep-00
Mar-01
Sep-01
Mar-02
Sep-02
Mar-03
Sep-03
Mar-04
Sep-04
Mar-05
Date
Nitrate
Sulfate
Uranium

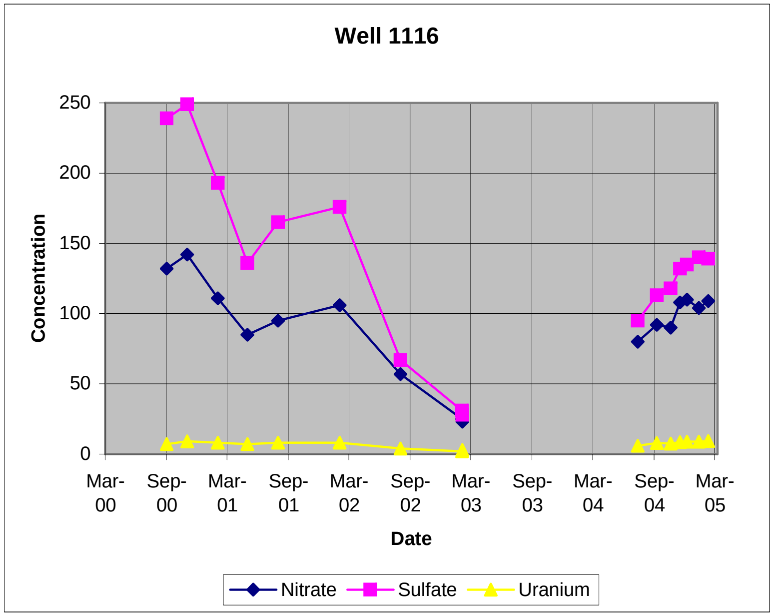

Well 1114
Concentration
4000
3500
3000
2500
2000
1500
1000
500
0
Mar-00
Sep-00
Mar-01
Sep-01
Mar-02
Sep-02
Mar-03
Sep-03
Mar-04
Sep-04
Mar-05
Date
Nitrate
Sulfate
Uranium

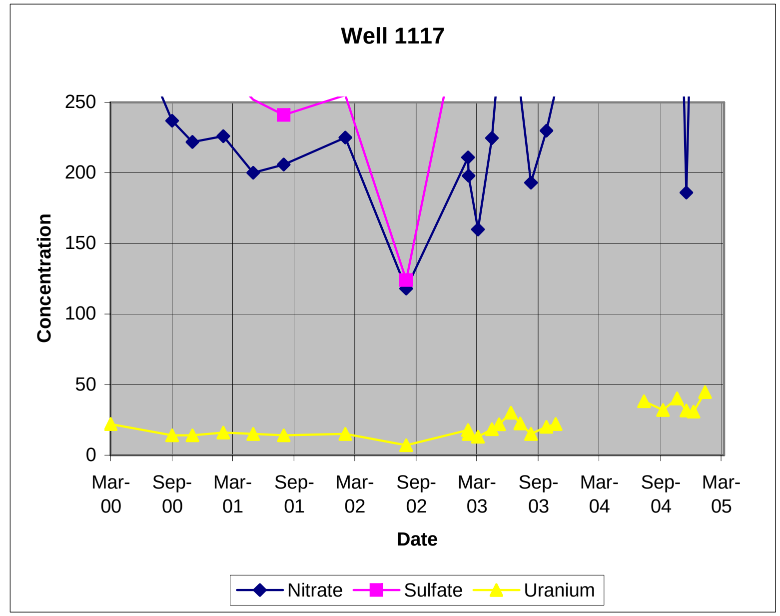

Well 1114
Concentration
0
50
100
150
200
250
Mar-00
Sep-00
Mar-01
Sep-01
Mar-02
Sep-02
Mar-03
Sep-03
Mar-04
Sep-04
Mar-05
Date
Nitrate
Sulfate
Uranium

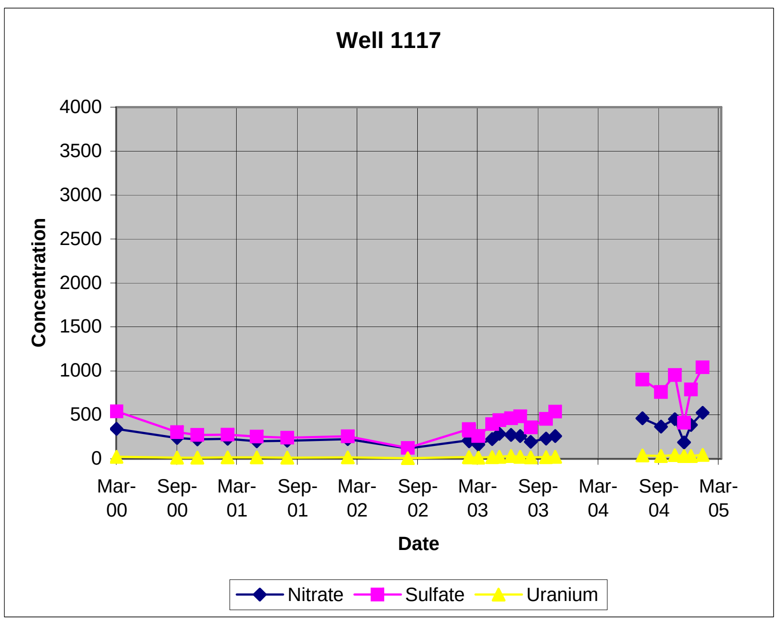

Well 1115
Concentration
0
50
100
150
200
250
Mar-00
Sep-00
Mar-01
Sep-01
Mar-02
Sep-02
Mar-03
Sep-03
Mar-04
Sep-04
Mar-05
Date
Nitrate
Sulfate
Uranium

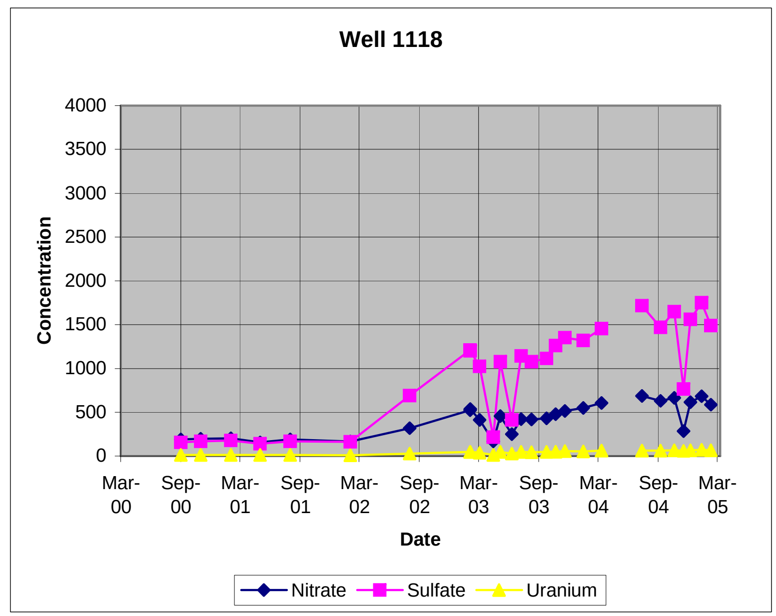

Well 1115
Concentration
0
500
1000
1500
2000
2500
3000
3500
4000
Mar-00
Sep-00
Mar-01
Sep-01
Mar-02
Sep-02
Mar-03
Sep-03
Mar-04
Sep-04
Mar-05
Date
Nitrate
Sulfate
Uranium

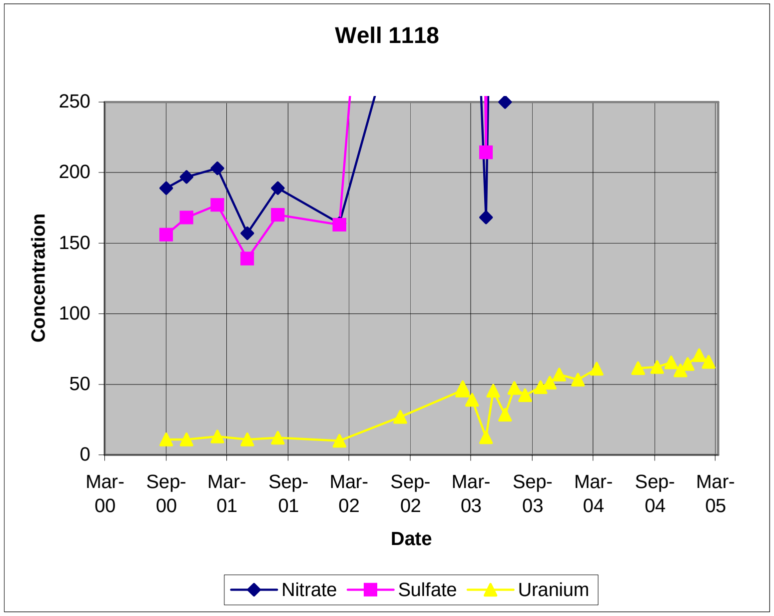

Well 1116
Concentration
0
500
1000
1500
2000
2500
3000
3500
4000
Mar-00
Sep-00
Mar-01
Sep-01
Mar-02
Sep-02
Mar-03
Sep-03
Mar-04
Sep-04
Mar-05
Date
Nitrate
Sulfate
Uranium

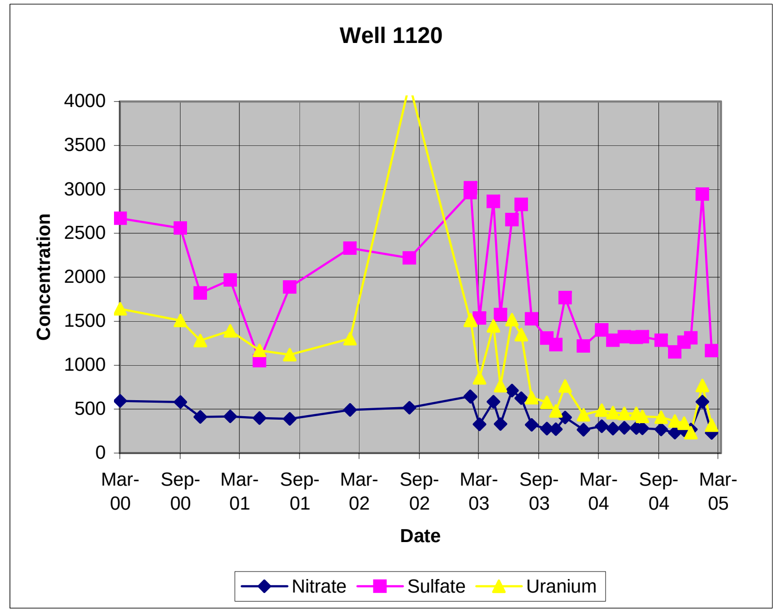

Well 1116
Concentration
Date
250
200
150
100
50
0
Mar-00
Sep-00
Mar-01
Sep-01
Mar-02
Sep-02
Mar-03
Sep-03
Mar-04
Sep-04
Mar-05
Nitrate
Sulfate
Uranium


Well 1117
Concentration
Date
250
200
150
100
50
0
Mar-00
Sep-00
Mar-01
Sep-01
Mar-02
Sep-02
Mar-03
Sep-03
Mar-04
Sep-04
Mar-05
Nitrate
Sulfate
Uranium


Well 1117
Concentration
Date
4000
3500
3000
2500
2000
1500
1000
500
0
Mar-00
Sep-00
Mar-01
Sep-01
Mar-02
Sep-02
Mar-03
Sep-03
Mar-04
Sep-04
Mar-05
Nitrate
Sulfate
Uranium


Well 1118
Concentration
Date
4000
3500
3000
2500
2000
1500
1000
500
0
Mar-00
Sep-00
Mar-01
Sep-01
Mar-02
Sep-02
Mar-03
Sep-03
Mar-04
Sep-04
Mar-05
Nitrate
Sulfate
Uranium


Well 1118
Concentration
250
200
150
100
50
0
Mar-00
Sep-00
Mar-01
Sep-01
Mar-02
Sep-02
Mar-03
Sep-03
Mar-04
Sep-04
Mar-05
Date
Nitrate
Sulfate
Uranium


Well 1120
Concentration
4000
3500
3000
2500
2000
1500
1000
500
0
Mar-00
Sep-00
Mar-01
Sep-01
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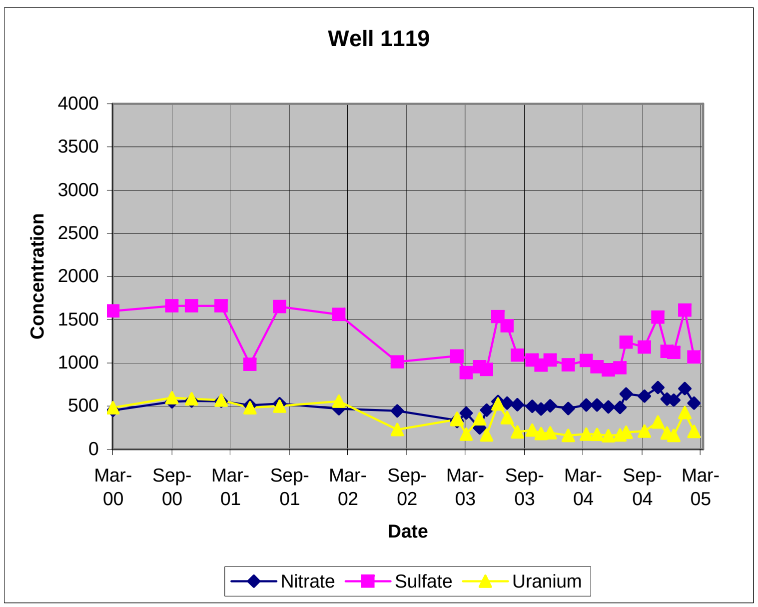
Sep-02
Mar-03
Sep-03
Mar-04
Sep-04
Mar-05
Date
Nitrate
Sulfate
Uranium


Well 1119
Concentration
4000
3500
3000
2500
2000
1500
1000
500
0
Mar-00
Sep-00
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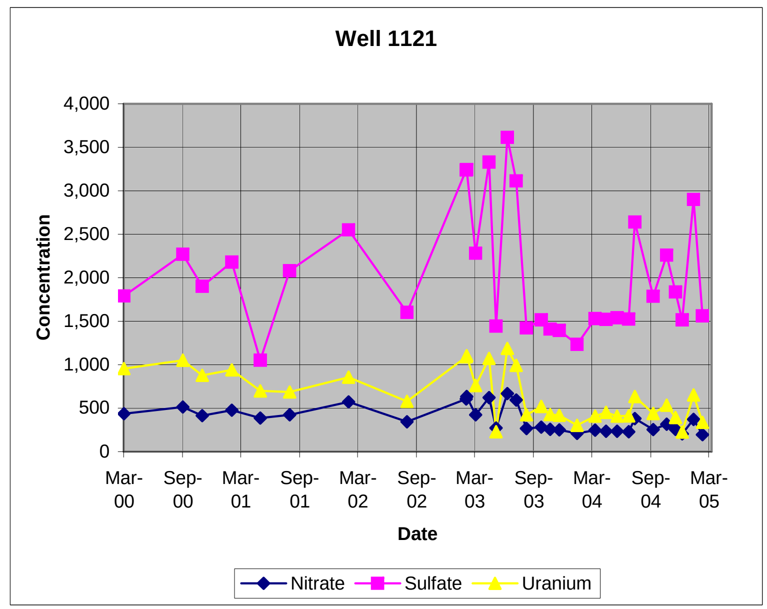
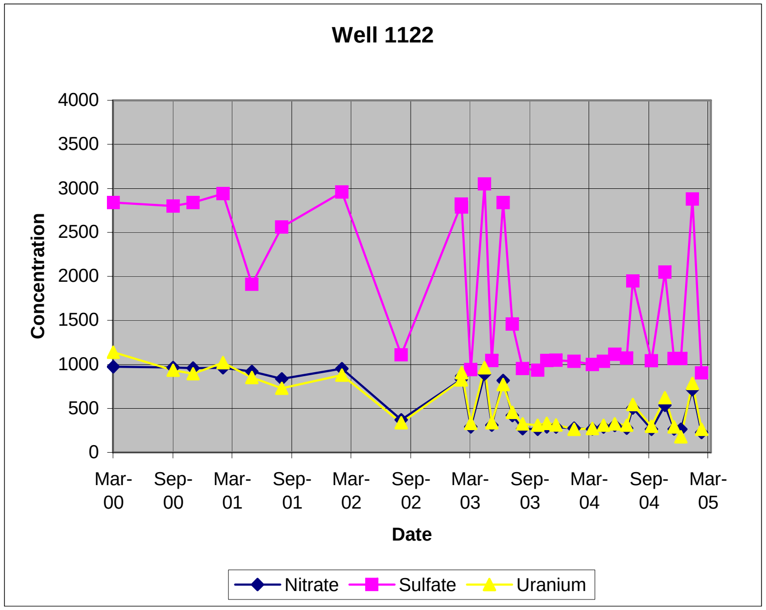
Sep-02
Mar-03
Sep-03
Mar-04
Sep-04
Mar-05
Date
Nitrate
Sulfate
Uranium


Well 1121
Concentration
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
Mar-00
Sep-00
Mar-01
Sep-01
Mar-02
Sep-02
Mar-03
Sep-03
Mar-04
Sep-04
Mar-05
Date
Nitrate
Sulfate
Uranium


Well 1122
Concentration
4000
3500
3000
2500
2000
1500
1000
500
0
Mar-00
Sep-00
Mar-01
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Mar-02
Sep-02
Mar-03
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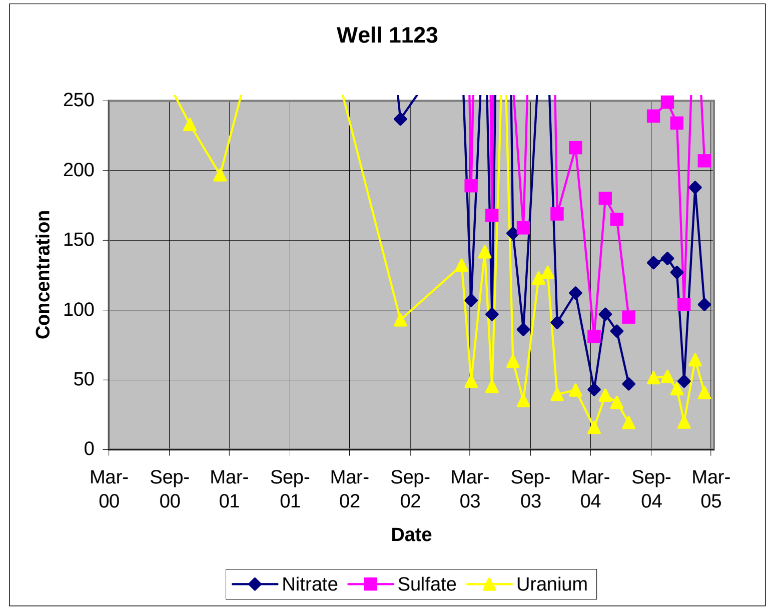
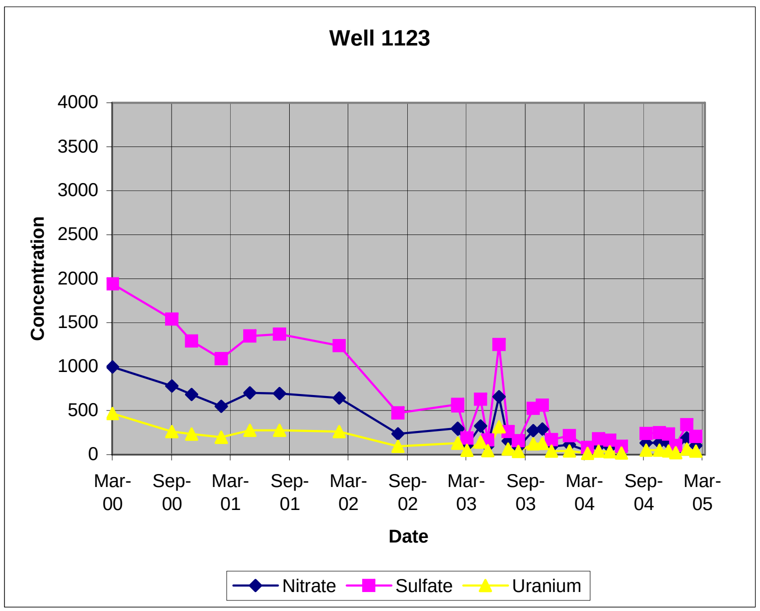
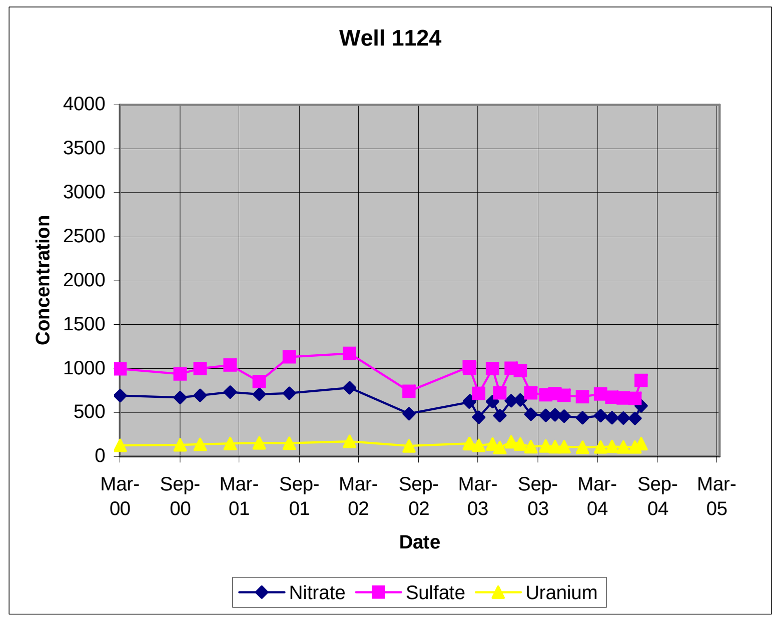
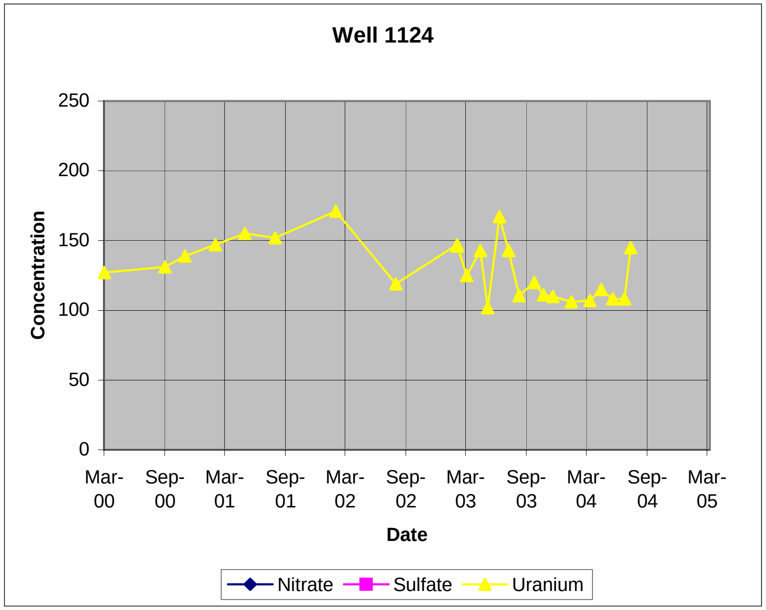
Mar-04
Sep-04
Mar-05
Date
Nitrate
Sulfate
Uranium


Well 1123
Concentration
250
200
150
100
50
0
Mar-00
Sep-00
Mar-01
Sep-01
Mar-02
Sep-02
Mar-03
Sep-03
Mar-04
Sep-04
Mar-05
Date
Nitrate
Sulfate
Uranium


Well 1123
Concentration
4000
3500
3000
2500
2000
1500
1000
500
0
Mar-00
Sep-00
Mar-01
Sep-01
Mar-02
Sep-02
Mar-03
Sep-03
Mar-04
Sep-04
Mar-05
Date
Nitrate
Sulfate
Uranium


Well 1124
Concentration
4000
3500
3000
2500
2000
1500
1000
500
0
Mar-00
Sep-00
Mar-01
Sep-01
Mar-02
Sep-02
Mar-03
Sep-03
Mar-04
Sep-04
Mar-05
Date
Nitrate
Sulfate
Uranium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Concentration
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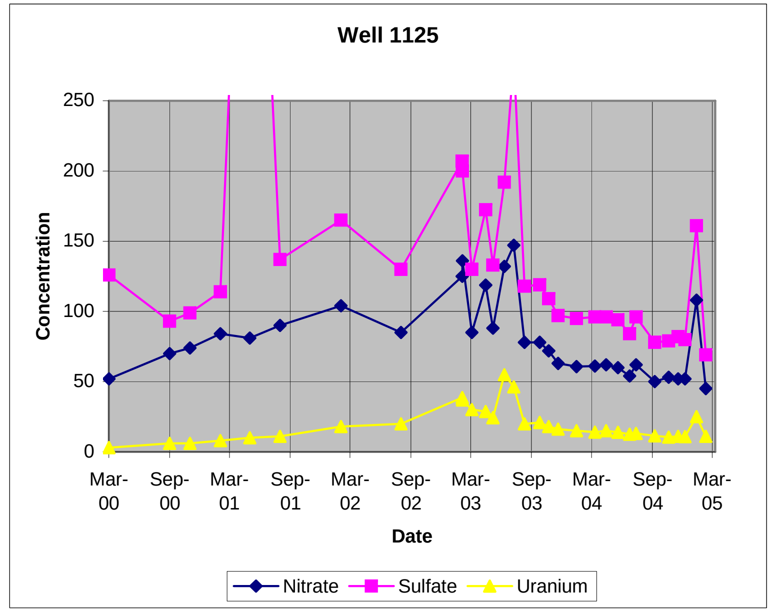
200
150
100
50
0
Mar-00
Sep-00
Mar-01
Sep-01
Mar-02
Sep-02
Mar-03
Sep-03
Mar-04
Sep-04
Mar-05
Date
Nitrate
Sulfate
Uranium


Well 1125
Concentration
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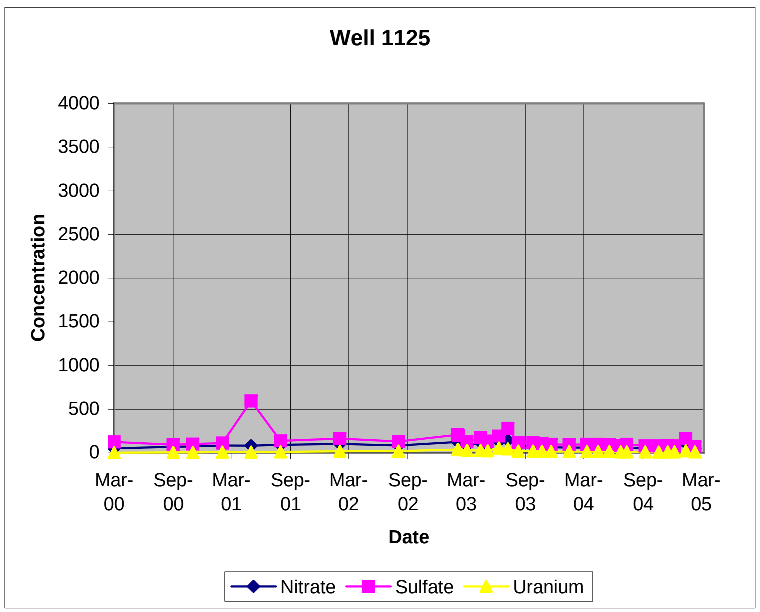
200
150
100
50
0
Mar-00
Sep-00
Mar-01
Sep-01
Mar-02
Sep-02
Mar-03
Sep-03
Mar-04
Sep-04
Mar-05
Date
Nitrate
Sulfate
Uranium


Well 1125
Concentration
4000
3500
3000
2500
2000
1500
1000
500
0
Mar-00
Sep-00
Mar-01
Sep-01
Mar-02
Sep-02
Mar-03
Sep-03
Mar-04
Sep-04
Mar-05
Date
Nitrate
Sulfate
Uranium

Appendix F

Estimated Initial Mass of Dissolved Contamination and Initial Volume of Contaminated Ground Water

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Calculation Set
Tuba City Site
Year 2005 Annual Performance Evaluation Report
Period of Review: March 2004 through March 2005

Objective: estimate the baseline volume of contaminated groundwater of the Middle Terrace; estimate the baseline mass of dissolved nitrate,sulfate, and uranium in the groundwater

Method:
1) estimate the area of the plume from baseline contaminant maps separately for Horizons A and B combined and Horizons C and D combined
2) estimate the vertical thickness of contamination for Horizons A and B combined and Horizons C and D combined
3) assume 25% porosity and compute the separate plume volumes for Horizons A and B combined and Horizons C and D combined
4) compute separate concentration averages for sulfate and uranium for Horizons A and B combined and Horizons C and D combined from baseline contaminant maps
5) multiply concentration average by plume volume to determine contaminant mass for Horizons A and B combined and Horizons C and D combined
6) sum the volume and mass estimates

Calcualtion:

1) map area of contaminant plume

Horizons A and B	plume length (northeast to southwest	4,000 ft
	plume width	1,800 ft
	area	7,200,000 ft^2
Horizons C and D	plume length (northeast to southwest	2,500 ft
	plume width	1,800 ft
	area	4,500,000 ft^2

2) thickness of contamination

Horizons A and B	25 ft
thickness Horizon A	50 ft
thickness Horizon B	75 ft
A&B combined thickness	

...approximately the upper half of Horizon A not saturated during baseline period
...Horizon B is fully saturated

Horizons C and D	
thickness Horizon C	50 ft
thickness Horizon D	25 ft
C&D combined thickness	75 ft

...entire thickness of Horizon C contaminated
...Horizon D not contaminated at many locations, assume 50% contaminated thickness

3) plume volumes

Horizons A and B	volume of contaminated groundwater	135,000,000 ft^3	**135,000,000 ft^3**
		1,012,500,000 gal	**1,013,000,000 gal**
		3,832,312,500 L	**3,832,000,000 L**
Horizons C and D	volume of contaminated groundwater	28,125,000 ft^3	**28,000,000 ft^3**
		210,937,500 gal	**211,000,000 gal**
		798,398,438 L	**798,000,000 L**

4) baseline concentrations

Horizons A and B

well	Horizon	U mg/L	sulfate mg/L	nitrate mg/L as NO3
262	B	0.379	931	380
263	B	0.485	1990	1140
265	B	0.090	1520	720
267	B	0.073	3680	1640
906	A	0.951	1660	1470
908	B	0.122	2430	651
909	B	0.040	666	485
934	B	0.312	7360	2320
936	B	0.267	4360	2950
940	A	0.546	7550	1800
941	A	0.089	745	358
942	B	0.246	3030	1360
944	B	0.950	1590	1010
geometric mean mg/L		0.231	2174	1028

Horizons C and D

well	Horizon	U mg/L	sulfate mg/L	N mg/L as NO3
1101	D	0.245	960	438
1102	D	0.533	1320	650
1103	D	0.355	2570	1120
1104	D	0.194	1870	993
1105	D	2.100	1590	648
1106	D	2.100	1050	614
1107	D	0.118	1200	1060
1108	D	0.646	3400	1410
1109	D	0.565	3280	798
1110	D	0.053	512	227
1111	D	0.161	988	421
1112	D	0.130	1140	617
1113	D	0.053	250	143
1114	D	0.040	328	228
1115	D	0.410	1930	766
1116	D	0.040	250	106
1117	D	0.040	255	225
1118	D	0.040	250	164
1119	D	0.555	1560	468
1120	D	1.3	2330	493
1121	D	0.849	2590	535
1122	D	0.878	2960	954
1123	D	0.261	1240	643
1124	D	0.171	1170	781
1125	D	0.04	250	104
912	C	0.04	846	403
	geometric mean mg/L	0.214	1020	464

5) mass calculation

Horizons A and B	mass uranium	884 kg
		1,949 lb
	mass sulfate	8,330,201 kg
		18,359,764 lb
	mass N as NO3	3,940,636 kg
		8,685,162 lb
Horizons C and D	mass uranium	171 kg
		377 lb
	mass sulfate	814,310 kg
		1,794,738 lb
	mass N as NO3	370,337 kg
		816,223 lb

6) total volume and masses

total volume contaminated groundwater	**163,000,000 ft^3**
	1,222,500,000 gal
	4,627,162,500 L
total mass uranium	**1,055 kg**
	2,326 lb
total mass sulfate	**9,144,511 kg**
	20,154,502 lb
total mass nitrate as NO3	**4,310,973 kg**
	9,501,384 lb

Calculation Set										
Tuba City Site										
Annual Performance Evaluation Report										
Period of Review: March 2004 through March 2005										
Objective:	estimate aquifer cleanup times									
Method:	compare mass and volume removed as of April 1, 2005 to estimates of initial contaminant inventory; predict cleanup time calculated removal rates to date									
Calculation:	estimate #1: initial contaminant volume and mass estimates from DOE Baseline Performance Evaluation, May 2003.									
	estimate #2: initial contaminant volume and mass estimates recalculated for March 2004 - March 2005 Performance Evaluation Report									
Estimate #1										
	initial mass lb	cumulative removed lb	% removed			initial vol gal	cumulative removed gal	# pore vols removed	% plume vol removed	
Nitrate	12,400,000	459,000	4			3.40E+09	135,900,000	0.040	4	
Sulfate	17,900,000	1,123,000	6			2.70E+09	135,900,000	0.050	5	
Uranium	2,800	325	12			3.00E+09	135,900,000	0.045	5	
	mass removal rate % per yr	cleanup time, yrs	cleanup date	# yrs until cleanup			pore volume removal rate % / yr	1-pore volume cleanup time, yrs	1-pore volume cleanup date	# yrs until cleanup
Nitrate	1.3	**76**	2078	73			1.4	**70**	2072	67
Sulfate	2.2	**45**	2047	42			1.8	**56**	2058	53
Uranium	4.1	**24**	2026	21			1.6	**62**	2064	59
t1=	15-Jun-02									
t2=	01-Apr-05									
t2 - t1=	2.8	yrs								
Estimate #2										
	initial mass lb	cumulative removed lb	% removed			initial vol gal	cumulative removed gal	# pore vols removed	% plume vol removed	
Nitrate	9,500,000	459,000	5			1.20E+09	135,900,000	0.113	11	
Sulfate	20,000,000	1,123,000	6			1.20E+09	135,900,000	0.113	11	
Uranium	2,300	325	14			1.20E+09	135,900,000	0.113	11	
Projection	mass removal rate % per yr	cleanup time, yrs	cleanup date	# yrs until cleanup			pore volume removal rate % / yr	1-pore volume cleanup time, yrs	1-pore volume cleanup date	# yrs until cleanup
Nitrate	1.7	**58**	2060	55			4.0	**25**	2027	22
Sulfate	2.0	**50**	2052	47			4.0	**25**	2027	22
Uranium	5.1	**20**	2022	17			4.0	**25**	2027	22
t1=	15-Jun-02									
t2=	1-Apr-05									
t2 - t1=	2.8	yrs								

Appendix G

Aquifer Restoration Index Calculation

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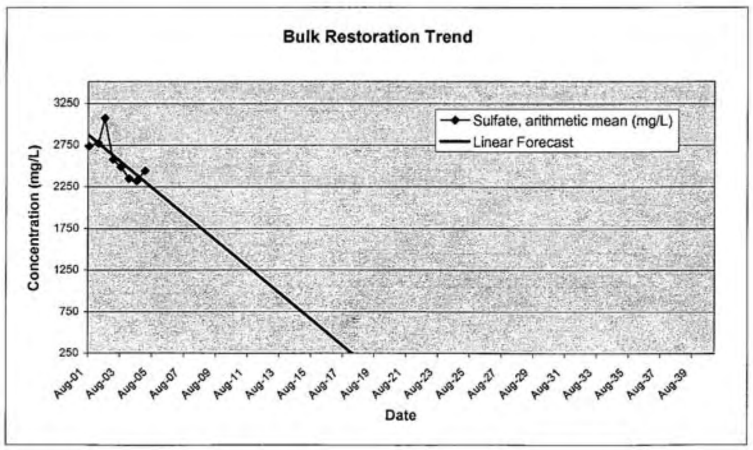
Calculation Set
Tuba City Site
Annual Performance Evaluation Report
Period of Review: March 2004 through March 2005

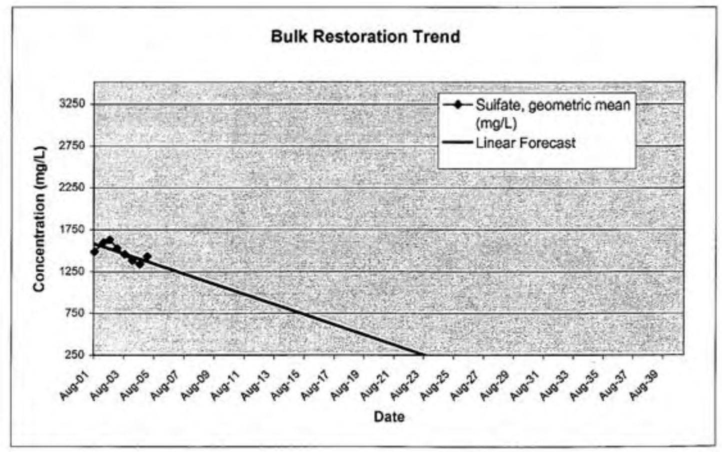
Objective: develop a bulk concentration index for measuring restoration progress for sulfate

Method: 1) compute an average concentration of a contaminant for a given sampling date/event for a selected group of monitor wells within the contaminant plume
2) compare the computed averages over time

Calculation: the selected monitor wells below have the most comprehensive data set and are located throughout the contaminant plume in Horizons A and B;
no historical data exists for Horizons C and D within the contaminant plume
note: where data are absent in the table below, concentrations are carried forward from the previous date as shown in ***bold italic***

	Sulfate (mg/L)														Sulfate,	Sulfate,
date_sampled	Loc 0262	Loc 0263	Loc 0265	Loc 0267	Loc 0906	Loc 0908	Loc 0909	Loc 0929	Loc 0934	Loc 0936	Loc 0940	Loc 0941	Loc 0942		arithmetic mean (mg/L)	geometric mean (mg/L)
08/16/2001	***931***	***1990***	***1520***	3620	1840	2310	419	19.9	7450	4570	7230	620	3030	baseline	2735	1482
03/06/2002	***931***	***1990***	***1520***	3680	1660	2430	666	28.1	7360	4360	7550	745	3030	baseline	2765	1594
08/20/2002	***931***	***1990***	***1520***	3530	1690	2330	637	27.9	11900	4400	***7550***	***745***	2680		3072	1625
02/06/2003	***931***	***1990***	***1520***	3550	1660	2430	629	27.6	2970	4880	9180	920	2790		2575	1524
08/06/2003	1190	1640	1070	3690	1650	2400	564	29.1	2640	3240	10300	1010	2890		2486	1453
02/12/2004	***1190***	***1640***	***1070***	***3690***	***1650***	2400	540	***29.1***	1900	3200	9600	800	2800		2347	1375
08/31/2004	1000	1900	800	3500	1700	2600	590	26	2300	2500	***9600***	710	2900		2317	1331
02/10/2005	1000	2100	810	3700	1900	3000	680	26	2300	2700	***9600***	890	3000		2439	1426





t1=	15-Jun-02
t2=	1-Apr-05
t2 - t1=	2.8 yr
t3=	Aug-18

projected cleanup time from t1= 16 yr
projected cleanup time from t2= 13 yr

t1=	15-Jun-02
t2=	1-Apr-05
t2 - t1=	2.8 yr
t3=	Aug-23

projected cleanup time from t1= 21 yr
projected cleanup time from t2= 18 yr

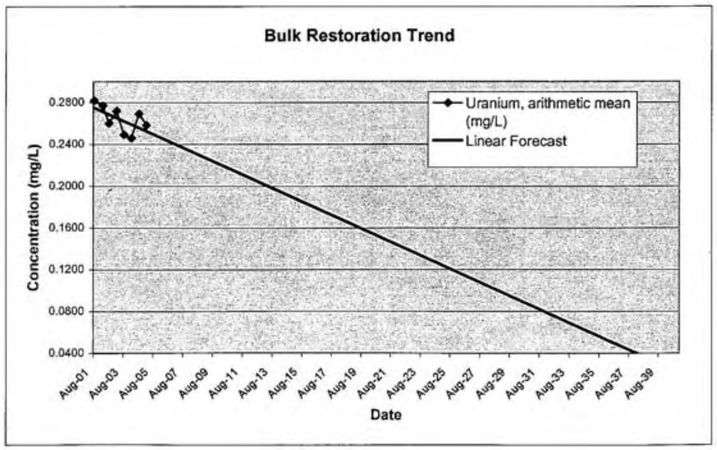
Calculation Set
Tuba City Site
Annual Performance Evaluation Report
Period of Review: March 2004 through March 2005

Objective: develop a bulk concentration index for measuring restoration progress for uranium

Method: 1) compute an average concentration of a contaminant for a given sampling date/event for a selected group of monitor wells within the contaminant plume
2) compare the computed averages over time

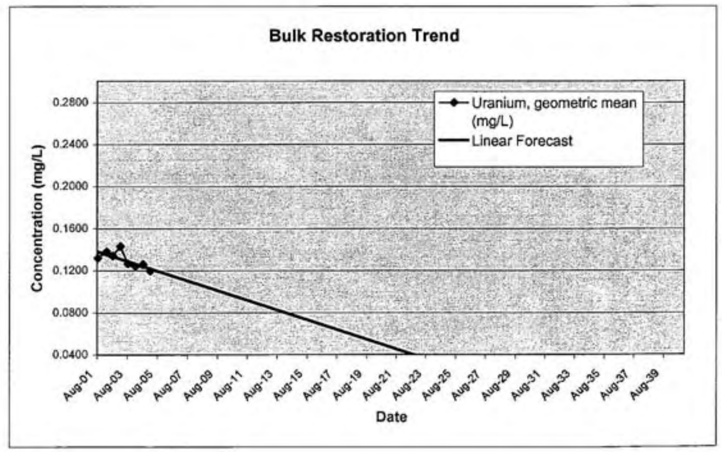
Calculation: the selected monitor wells below have the most comprehensive data set and are located throughout the contaminant plume in Horizons A and B;
no historical data exists for Horizons C and D within the contaminant plume
note: where data are absent in the table below, concentrations are carried forward from the previous date as shown in ***bold italic***

	Uranium mg/L														Uranium,	Uranium,
date_sampled	**Loc 0262**	**Loc 0263**	**Loc 0265**	**Loc 0267**	**Loc 0906**	**Loc 0908**	**Loc 0909**	**Loc 0929**	**Loc 0934**	**Loc 0936**	**Loc 0940**	**Loc 0941**	**Loc 0942**		**arithmetic mean (mg/L)**	**geometric mean (mg/L)**
08/16/2001	***0.3790***	***0.4850***	***0.0897***	0.0696	0.9340	0.1110	0.0178	0.0012	0.2980	0.2810	0.6430	0.1030	0.2510	baseline	0.2818	0.1316
03/06/2002	***0.3790***	***0.4850***	***0.0897***	0.0731	0.9510	0.1220	0.0389	0.0012	0.3120	0.2670	0.5460	0.0886	0.2460	baseline	0.2769	0.1378
08/20/2002	***0.3790***	***0.4850***	***0.0897***	0.0742	0.6980	0.1220	0.0349	0.0011	0.3360	0.3060	***0.5460***	***0.0886***	0.2180		0.2599	0.1336
02/06/2003	***0.3790***	***0.4850***	***0.0897***	0.0765	0.6530	0.1240	0.0333	0.0015	0.3550	0.5820	0.4320	0.1020	0.2210		0.2718	0.1428
08/06/2003	0.4250	0.1730	0.0551	0.0784	0.6670	0.1060	0.0279	0.0018	0.3500	0.6060	0.4280	0.0858	0.2320		0.2489	0.1261
02/12/2004	***0.4250***	***0.1730***	***0.0551***	***0.0784***	***0.6670***	0.0970	0.0270	***0.0018***	0.3200	0.6000	0.4300	0.0810	0.2400		0.2458	0.1238
08/31/2004	0.5300	0.2300	0.0450	0.0880	0.8900	0.1200	0.0290	0.0010	0.3200	0.4700	***0.4300***	0.0760	0.2700		0.2692	0.1256
02/10/2005	0.5600	0.1900	0.0450	0.0850	0.8300	0.1100	0.0350	0.0010	0.2800	0.4700	***0.4300***	0.0490	0.2700		0.2581	0.1191



t1= 15-Jun-02
t2= 1-Apr-05
t2 - t1= 2.8 yr
t3= Aug-37

projected cleanup time from t1= 35 yr
projected cleanup time from t2= 32 yr



t1= 15-Jun-02
t2= 1-Apr-05
t2 - t1= 2.8 yr
t3= Aug-22

projected cleanup time from t1= 20 yr
projected cleanup time from t2= 17 yr